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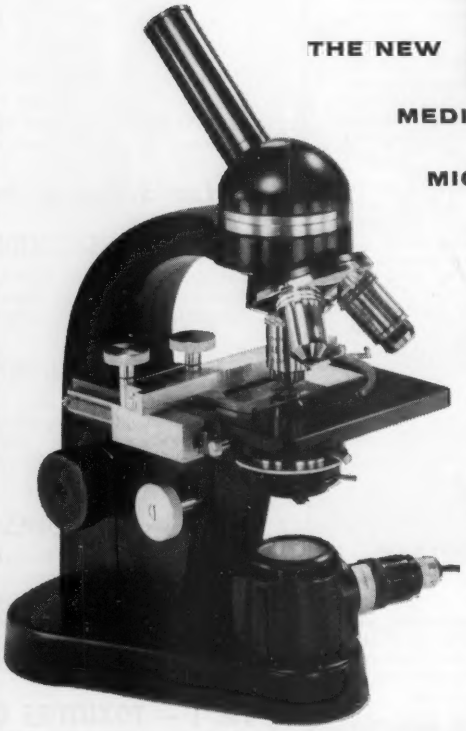

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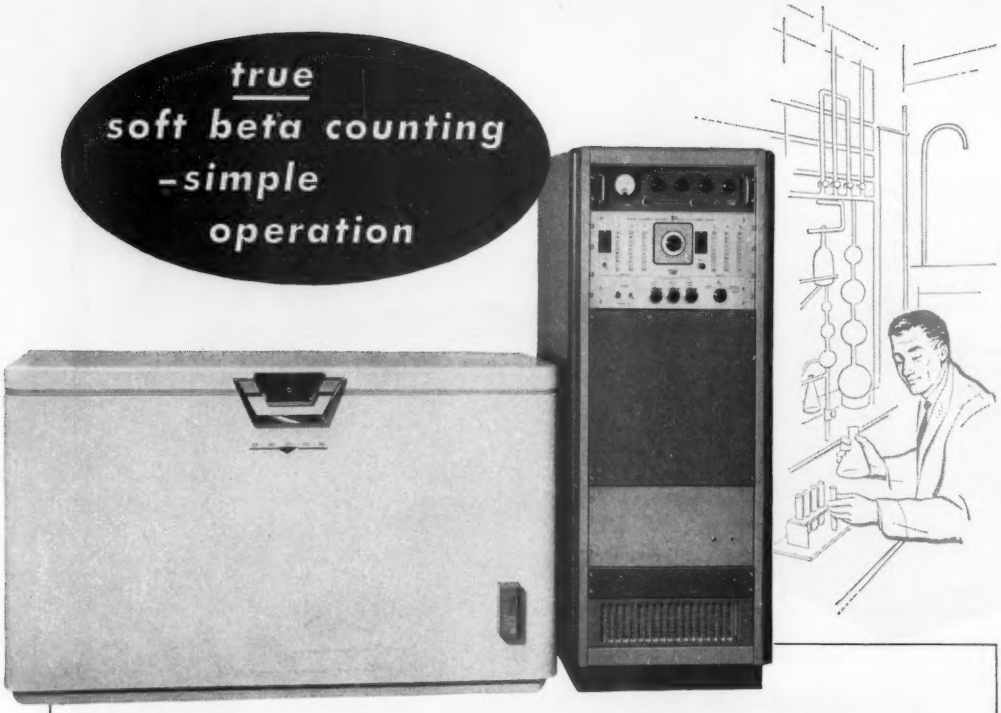

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Author's Choice

Science has recently been the target of several pot shots from other members of the publishing world. The criticism started, so far as we know, when an alert science writer of the *Washington Post and Times Herald* discovered that "Strontium-90 in Man III," the article on page 1249, was in the *Science* office but had not yet been published. Because the concentration of strontium-90 is a matter of general concern, because the authors had chosen to have their report published in *Science* instead of giving prior release to the newspapers, and because the interval between receipt of the article and its appearance was longer than the reporter thought justified, he concluded that *Science* was either negligently slow in bringing important information to the public or was willfully withholding that information.

Under the title "Strontium-90 in U. S. Children, the Report That the AEC is Withholding," *The Nation* then went off in two directions. It censured the Atomic Energy Commission and *Science* for "sitting on" an article of vital public concern, and then argued that the data are so limited that the conclusions lack significance and do not give anything like a true picture of the strontium-90 situation. The *New York Times* then joined the attack with a summary of *The Nation* article.

The critics claim that the report should have been given to the general press instead of being sent to *Science*, a journal that *The Nation* describes as a "respected but highly technical publication of limited circulation." (We accept this description, but with amusement point out that *Science* has twice the circulation of *The Nation*.)

The claim raises a question that merits clearer formulation than the critics have supplied: Under what circumstances should the traditional customs of scientific publication be followed, and under what circumstances is it preferable to give a scientific report to the public press prior to its appearance in a scientific journal? The research worker has a choice. If he presents his material in an open meeting or gives it directly to the press, newspapers can report it immediately. The material reaches the public quickly—if at all—but relatively unscreened and rarely in sufficient detail to enable other scientists to form their own judgments about the adequacy of the conclusions.

If the report is published in a scientific journal, it does not reach the public as quickly, but when it does, it has survived critical scientific review, has frequently been made clearer as a result of suggestions from the editor or referee, and is published in sufficient detail to enable scientific colleagues to appraise data and methods as well as conclusions.

Custom dictates that the choice be made by the scientist rather than by the institution that supported the work or the editor to whom the account of it is submitted. Both alternatives have their proper uses, but there is not yet agreement on the conditions under which each is preferable. Until agreement is reached on the criteria for each, we will honor the choice an author makes when he sends an article to *Science*. We will continue to have articles critically reviewed and will publish the accepted ones in sufficient detail to enable other scientists to gain more information than they can normally get from newspaper accounts. Note, however, that when an author wishes to reach the public more quickly, there is an alternative channel open to him.

We think it desirable that both scientists and journalists have a clear understanding of the nature of these options.—D.W.

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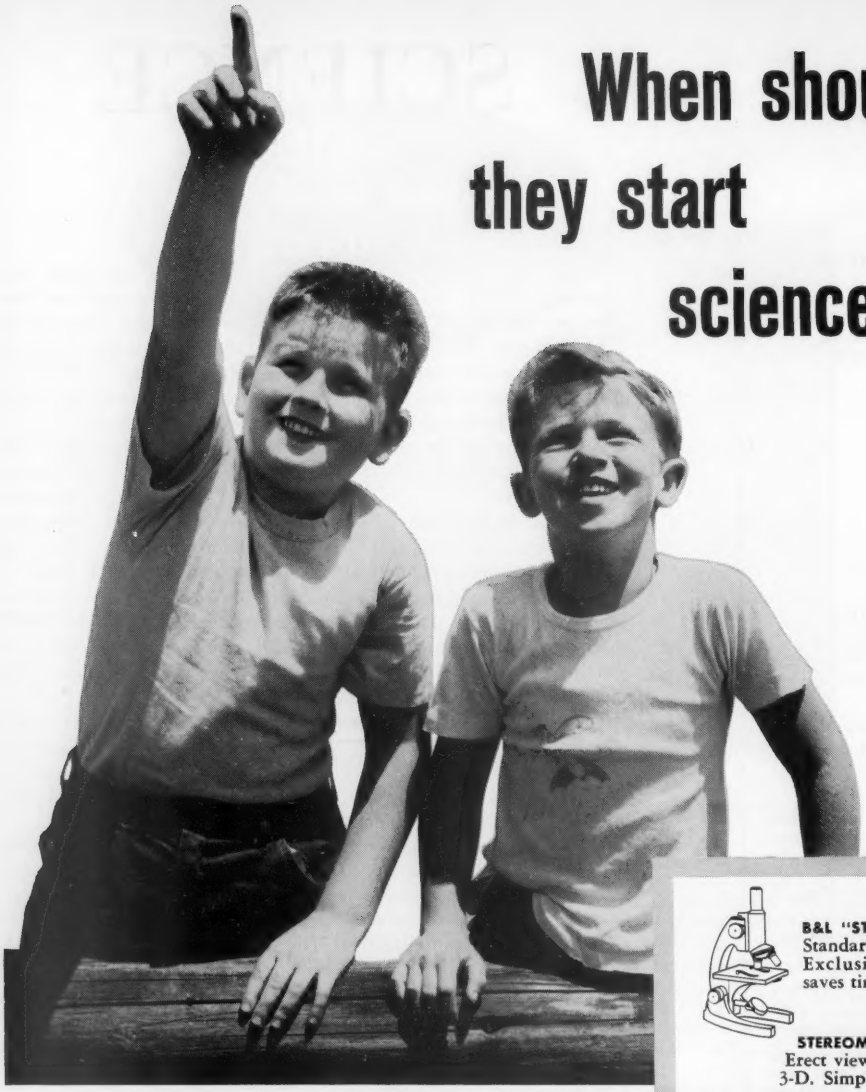

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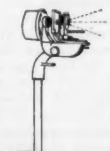

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Strontium-90 in Man III

The annual increase of this isotope and its pattern of world-wide distribution in man are defined.

J. Laurence Kulp, Arthur R. Schulert, Elizabeth J. Hodges

The investigation of the mechanism of the distribution of strontium-90 from nuclear detonations and its uptake in man has continued. This article (*1*) presents new data on strontium-90 concentration in human bone, largely from samples obtained in 1957–58. The measurements extend the earlier work (*2, 3*) in time and location and add details which give greater understanding of the principles of the movement of strontium-90 in the biosphere. The results of the past year also clearly define the annual increment in strontium-90 in the skeleton for the years 1953 to 1957 in a single location (New York City).

The ultimate goal of this study is to predict the future distribution of strontium-90 for the entire world population. Enough data have been obtained on the strontium-90 levels in human bone, in food, in soil, and in rainfall as a function of geographical location so that a first approximation to the world distribution curve can be made. The curve for the present distribution of strontium-90 in adults has been calculated and this is used to predict the distribution for young children in 1966, when the maximum level of strontium-90 in the diet from tests made to date will have been reached.

Experimental Procedures

Samples of human bone are received at regular intervals from about 35 stations in a world-wide network. During 1957–58 an attempt was made to divide the samples somewhat equally according to whether the individuals had been older or younger than 20 years at death. Since it appeared from earlier work (*3*) and from data given in Table 1 that age is not an important determinant of the amount of strontium-90 deposited in adults, equal portions of adult bone from a given locality were integrated to reduce the number of analyses required. Exceptions to this practice were made where new stations were involved, in order that data on local variation might be obtained. Individual samples containing less than 3.0 grams of calcium in the case of an adult or 1.0 gram of calcium in the case of a child were not analyzed during 1957–58, since larger statistical counting errors result from the inclusion of such samples, as a result of the small quantity of strontium-90 that is present.

Most of the bone analyses were made by two commercial laboratories (*4*). Some analyses and intercalibration tests were performed at this laboratory, by methods described elsewhere (*5*).

The samples were all single bones (some were integrated samples) with the exception of 160 whole skeletons obtained from cadavers in New York City. Measurements have shown that the distribution of natural strontium is uniform in the adult skeleton to within at least 10 percent (*6*). Detailed studies in adults in which strontium-85 and calcium-45 tracers were used (*7*), and studies of fallout strontium-90 in both children and adults (*8*) show that the strontium-90 from the diet is nearly uniform in the bones of the skeletons of young children, while in the bones of adults it occurs in different concentrations that are systematic and reproducible. Schulert *et al.* (*8*) have determined these relations and have shown that the average concentration of strontium-90 in a particular adult skeleton can be estimated from the analysis of a single bone of that skeleton. The results reported below are all given in micromicrocuries of strontium-90 per gram of calcium. In the case of children, the level of strontium-90 in a single bone is taken as the skeletal average. The concentration of strontium-90 in the whole skeleton of an adult (of age 20 or more) is computed, by Schulert *et al.* (*8*), from the analysis of a single bone by using the actual strontium-90 distribution found in skeletons of people who died in 1957:

Vertebrae/whole skeleton = 1.8
Rib/whole skeleton = 1.0
Femur/whole skeleton = 0.5

The standard errors for these ratios are 12, 14, and 25 percent, respectively.

The uncertainty that results from computing the concentration of strontium-90 in the whole skeleton from the analysis of a single bone is generally less than the counting error attributable to the low activity levels of the single-bone samples. This is particularly true for the femur and for small samples of any adult bone (*8*).

Regional Averages and Time Effect

The concentrations of strontium-90 that were found in human bone from various localities in 1957–58 are compared in Table 2. All adult samples were combined for this purpose, since, as was noted above, no effect attributable to the age of the individual has been observed. Note that the samples for the United States have about the same concentration as the average for other parts of the world in the same latitude band. Note also that rice-diet areas (for example, Thailand, Japan, and the Philippines) have a concentration somewhat

The authors are on the staff of the Lamont Geological Observatory, Columbia University, Palisades, New York.

Table 1. Levels of strontium-90 in adult skeletons in relation to age. Samples were from the area of Western culture, 20° to 60° north latitude. Number of samples is given in parentheses.

Period	Level of Sr^{90} (μμc/g of Ca)				
	Age (yr)				
	20–29	30–39	40–49	50–59	Over 60
1955–1956	0.12 (93)	0.13 (80)	0.09 (22)	0.16 (4)	0.12 (9)
1956–1957	0.13 (56)	0.15 (36)	0.12 (42)	0.15 (48)	0.12 (62)
1957–1958	0.15 (3)	0.36 (12)	0.22 (14)	0.17 (9)	0.17 (77)

higher than the average. A world average of 0.19 μμc of strontium-90 per gram of calcium is obtained by weighting each latitude band according to its adult population but treating the Western and rice-diet areas separately. The standard deviation is given for localities contributing more than 20 samples, to give some idea of the spread encountered in samples from a given station. Larger variations generally indicate that the number of samples was small, and the mean values therefore fluctuate considerably from year to year for a given station (*3*). Also included in Table 2 is the latest estimate of the cumulative fallout per unit of rainfall for each latitude band to January 1958, based on all available determinations of strontium-90 in soil and rainfall. There is less apparent difference in the levels in bone than in the recorded fallout, between the Northern and Southern hemispheres (Tables 2 and 3). This fact may be due in part to the widespread flow of wheat and powdered milk from the Northern to the Southern Hemisphere. Other equalizing factors may be the higher rainfall of the local food-producing areas of the tropical regions and the higher ratio of vegetable calcium to milk calcium in the diet in the Southern Hemisphere.

Table 2. Regional averages for strontium-90 in adult skeletons in 1957–1958.

No. of samples	Location	Sr^{90} μμc/g of Ca)	Standard deviation	Cumulative fallout [mc of Sr^{90}/mi^2/unit of rainfall (Jan. 1958)]
	40° to 60°N			
13	Vancouver	0.30		
73	Boston	0.18	0.10	20
1	Denmark	0.17		
6	England	0.25		
18	Germany	0.14		
	20° to 40°N			
12	Houston	0.18		17
2	Taiwan	0.18		
22	Israel	0.18	0.13	
4	Japan	0.33		
4	Hawaii	0.15		
	0° to 20°N			
25	Puerto Rico	0.12	0.08	3
4	Colombia	0.07		
46	Guatemala	0.10	0.07	
4	Philippines	0.27		
21	Thailand	0.36	0.29	
	0° to 20°S			
13	Belgian Congo	0.21		4
	Ecuador	0.13		
	20° to 40°S			
16	Argentina	0.14		6
29	Chile	0.07	0.05	
4	Union of South Africa	0.18		
5	Cape Town	0.07		
36	Australia	0.20	0.11	

A general summary of the 1957–58 findings for samples of human bone of individuals who died at less than 20 years of age is given in Table 3. This is the largest number of samples for a single year yet obtained, and most of them were of sufficient size to give reasonably accurate analyses. Note the near-equality of the concentrations in North America and Europe in each category where an appreciable number of samples exists. The average difference in concentration for samples from the Northern and Southern hemispheres is in agreement with that obtained for adults.

The gradual build-up of strontium-90 in human bone that has occurred over the past four years is shown in a general way by the regional averages (Table 4). The anomalies reflect changes in the number and location of sampling stations during the three-year period. The best indication of the time effect is given by the whole-body samples from New York (Fig. 1); a large number of samples were available from this station, and the size of the samples made it possible to make more accurate analyses than could be made with smaller samples. It may be noted that the concentrations of strontium-90 in the skeletons of these cadavers was about 30 percent lower, on the average, than concentrations in other skeletons from the same area; this probably reflects the poorer nutritional state of these persons.

Strontium-90 in Children and Variation with Age

The concentration of strontium-90 varies with age for young people at the present time, since there has not been sufficient time for their skeletons to equilibrate with strontium-90 in the diet. Strontium-90 is deposited directly in the formation of new bone and through exchange and other turnover processes in preexisting bone. It is instructive to compute the concentration of strontium-90 as a function of age for a population with a given strontium-90 content in the diet and to compare this theoretical curve with the experimental data. Since the United States, Canada, and Europe appear to have strontium-90 levels in soil, food, and human skeletons that are closely similar (*9, 10*), bone samples from these areas can be grouped for this purpose, thus providing a larger number of samples to test the theory.

The calculation requires knowledge of: (i) the strontium-90 concentration in the average diet for the past five years; (ii) the discrimination factor for strontium relative to calcium from diet to bone; (iii) the number of grams of bone deposited per year at each age as a result of skeletal growth; and (iv) the magnitude of the average bone turnover per year.

The strontium-90 concentration in the average diet of individuals in these areas has been estimated from the data of the Atomic Energy Commission's Health and Safety Laboratory (*11*), the Lamont Geochemical Laboratory (*9, 12*) and the British group (*10, 13*). The re-

Fig. 1. Concentration of strontium-90 in whole skeletons of New York City adults.

Table 3. Level of strontium-90 in children's bones, 1957–1958. Number of samples is given in parentheses.

Age	Level of Sr^{90} (μμc/g of Ca)				
	North America	Europe*	South America	Asia	Africa, Australia
Fetus	0.64 (9)	0.60 (27)		1.3 (15)	0.25 (2)
0– 6 mo	1.18 (8)	1.15 (28)		0.21 (4)	0.45 (1)
7–12 mo	1.84 (1)	1.47 (5)	0.58 (38)	1.15 (4)	
1– 2 yr	1.53 (7)	1.39 (9)	0.54 (5)	0.11 (1)	0.27 (1)
2– 3 yr	1.49 (9)	1.71 (4)	1.28 (1)		0.60 (1)
3– 4 yr	1.23 (7)	0.87 (3)			0.43 (5)
4– 5 yr	0.74 (5)	0.73 (3)			0.48 (3)
5– 6 yr	0.70 (12)	0.66 (6)	0.28 (10)		0.55 (2)
6– 8 yr	0.60 (12)	0.61 (5)	0.39 (4)	0.28 (2)	0.53 (5)
8–10 yr	0.88 (11)	0.39 (4)	0.28 (8)	0.09 (1)	1.50 (2)
11–15 yr	0.51 (21)	0.55 (5)	0.22 (5)	0.50 (3)	0.49 (8)
16–19 yr	0.39 (11)	0.24 (3)	0.20 (15)	0.45 (2)	0.22 (4)

*Data from Bryant *et al.* (*28*) on European children for 1957–1958 were included to give a better comparison for Europe and North America.

sultant averages in micromicrocuries of strontium-90 per gram of calcium for North America and western Europe for 1 July of each year from 1953 through 1957 are 0.4, 1.6, 3.6, 5.1, and 6.5, respectively.

The data for the average amount of bone deposited per year are taken from Mitchell *et al.* (*14*) for males in the United States.

Schulert *et al.* (*7*) obtained a discrimination factor of 4 for calcium against strontium from diet to bone, on the basis of double-tracer (calcium-45, strontium-85) intravenous single doses in human patients and of previous work by Spencer *et al.* (*15*) on discrimination across the gastrointestinal wall in man. In an experimental study involving the stable strontium-to-calcium ratios in the normal diet and the skeletons of people in communities of Wales and northwest England, Bryant *et al.* (*10*) obtained a discrimination factor of 4 for calcium against strontium. Comar *et al.* (*16*) have obtained discrimination factors of about 2 and 4, respectively, for calcium against strontium from diet to bone for rats fed a milk and a nonmilk diet, and a discrimination factor of about 2 for several human patients on a milk diet. This suggests that the actual discrimination factor for human beings may depend somewhat on the diet. Nevertheless, the experiment of Bryant *et al.* (*10*) shows that the average discrimination factor for calcium against strontium in the average man in areas of Western culture must be close to 4. A placental discrimination factor of 2 was found by Comar in animals (*17*). The data in Fig. 2 for North America and Europe indicate that this factor is about the same in human beings.

If a discrimination factor of 4 for calcium against strontium from diet to bone is assumed, the average turnover rate for the normal adult can be calculated from the known concentration of strontium-90 in the diet over the past five years and the present average concentration of strontium-90 in adult bone. The result is 3.8 percent per year. If the behavior of strontium is assumed to be similar to that of calcium, a maximum of 1 percent may be accounted for by intracrystalline exchange, whereas perhaps another 1 percent is due to remodeling. The rest is accounted for by passage to the more spongy bone, where the rate of turnover is much higher. Once this latter reservoir becomes saturated, the apparent average turnover rate will drop to the intracrystalline exchange and remodeling rate. From the experimental data the gross average turnover for adults is calculated to be 3.8 percent per year during this period. It is assumed for purposes of calculation that this same rate applies to children, although their rate of turnover is probably higher. Since the proportion of calcium deposited in the process of growth relative to that deposited through turnover is large in the case of young children, no great uncertainty is introduced through basing the calculation for children on this rate.

Table 4. Levels of strontium-90 in adult bone from 1955 through 1958. Number of samples is given in parentheses.

Location	Sr^{90}(μμc/g of Ca)		
	1955–1956	1956–1957	1957–1958
40°–60°N	0.12 (177)	0.12 (176)	0.19 (111)
20°–40°N	0.14 (88)	0.13 (114)	0.19 (44)
0°–20°N	0.11 (130)	0.20 (63)	0.16 (101)
0°–20°S	0.07 (41)	0.08 (22)	0.25 (16)
20°–40°S	0.11 (88)	0.12 (78)	0.14 (90)

The theoretical curve computed in this way is given in Fig. 2 and is compared with the experimenal data for children's bones in North America and in western Europe obtained in this study and by Booker *et al.* (*13*). The standard deviation in the analyses for any given age group is about 30 percent of the mean for those sets in which there are at least eight samples. This variation is probably due primarily to individual differences in diet. It is seen that the points for the various age groups follow the curve reasonably well, the greatest divergence being found in early adolescence. The ratio of the maximum, which occurs at about age 1 year, to the adult average is about 8; this ratio will be reduced if the concentration of strontium-90 in the diet becomes more constant with time.

On the basis of the values given above for the bones of individuals in North America between the ages of 0 and 20, it is now possible to weight the level of strontium-90 in bone by the fraction of the population in each age group and thus to compute the present world average concentration of strontium-90 in human bone. This calculated world average as of 1 January 1958 is 0.52 μμc of strontium-90 per gram of calcium.

Future Human Burden of Strontium-90

The accumulation of new data relative to the concentration of strontium-90 in human bone and diet and to the deposition of strontium-90 on the earth's surface makes it possible to predict future levels in the human population with greater accuracy. This calculation is based upon atmospheric contamination from nuclear tests to the end of 1958 and on the assumption that the diet level is proportional to total fallout. The calculation tacitly implies that strontium-90 will be distributed in the future approximately as it has been in the past, although the Soviet tests of October 1958 may alter the distribution to a minor extent in the direction of increasing the amount deposited in the North Temperate Zone in the future. The quantities of greatest interest are the anticipated concentrations of strontium-90 in the diet and the related anticipated levels of strontium-90 in newly formed bone.

The concentration of strontium-90 in the average Western diet was 6.5 μμc

per gram of calcium on 1 July 1957, when the level in milk was 6.1 μμc per gram of calcium. A comprehensive survey of U.S. milk in the United States in July of 1958 gave an average of 8.2 μμc of strontium-90 per gram of calcium (*18*), which is equivalent to a level in the diet of 8.7 μμc of strontium-90 per gram of calcium. To extrapolate to 1 January 1959, it follows that the Western diet included 9.7 μμc of strontium-90 per gram of calcium on that date. Also, on 1 January 1959 the cumulative deposition of strontium-90 on the surface of the earth was about 2.2 megacuries (*19*). In the light of data on the isotopic composition of stratospheric debris that have been derived from new rain and from balloon sample analyses (*20*), it seems likely that the mean residence time of strontium-90 in the stratospheric reservoir is three years rather than the five (*21*) or ten (*22*) that have been estimated previously. From this figure and from the deposition rate it is possible to estimate that the stratospheric reservoir contained about 1.8 megacuries on 1 January 1959, exclusive of debris from the Soviet tests of October 1958. If the latter contributed as much as a major test series—for example, the United States' Redwing series of 1956 (*22*)—the total stratospheric reservoir would be about 2.6 megacuries. On the basis of these three assumptions—2.6 megacuries to be deposited, a mean residence time of about three years, and a discrimination factor of 4—when due allowance has been made for radioactive decay, the strontium-90 concentration in the diet, and hence in newly depositing bone, can be readily computed. The result (Fig. 3) shows that a peak in the level of strontium-90 in new bone will occur about 1966. The average concentration in the skeletons of young children on a Western diet in the Northern Hemisphere at that time will approach but not reach this peak level.

This estimate of the future levels that will be reached if there is no further introduction of fission debris into the atmosphere is probably maximal. One of the fundamental assumptions in the calculation is that the strontium-90 levels in the diet will be proportional to the *cumulative* fallout (*23*), and others have emphasized that the level in the diet may be related also to the *rate* of fallout, and that in some cases the rate factor may predominate. At present the data are not adequate for quantitative assessment of the relative importance of the rate factor. If it should be determined, for example, that as much as half of the uptake of strontium-90 by plants is due to the rate of fallout, the predicted curve might have to be lowered by as much as a factor of 2. The rate of fallout, however, did not change appreciably from 1954 to 1957, whereas the skeletal concentration of strontium-90 in an urban population increased markedly (Fig. 1). It is concluded, therefore, that cumulative fallout is the dominant factor for the average diet in areas of Western culture, but the data cannot rule out the possibility of a contribution from the rate factor which would reduce the predicted levels (Fig. 3). Other factors that would also reduce the levels in diets in the future would include loss of strontium-90 by vertical migration in the soil, or chemical fixation. Neither of these factors is considered significant (*19*). The plowing of pasture land, however, will probably cause some reduction in the levels of strontium-90 in food over those that have been predicted.

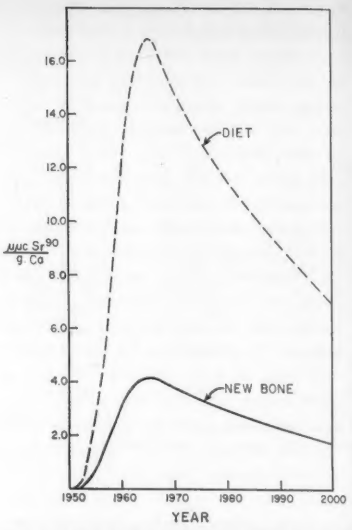

Fig. 3. Uptake of strontium-90 in food and new bone in the area of Western culture, 20° to 60°N.

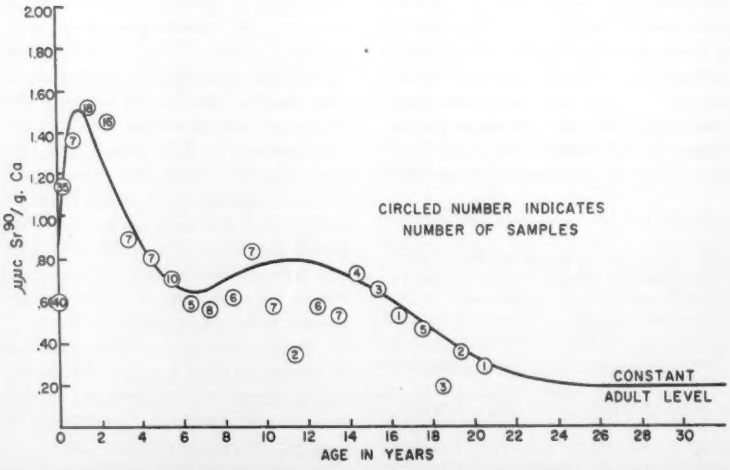

Fig. 2. Concentration of strontium-90 in the skeleton, in January 1958, in North America and western Europe.

World-wide Distribution

The other question of importance is that of the ultimate distribution of concentrations of strontium-90 in the world population. This is complicated to such an extent by the fact that there is great variation with age in children—a result of the rapidly changing levels of strontium-90 in the diet (Figs. 2 and 3)—that a histogram of all bone samples would not be significant. The fact that the strontium-90 concentration in adult bone is independent of age and that the average values over large geographical areas are rather similar provides a suitable characteristic for a frequency plot. As the rate of change of levels of strontium-90 in the diet decreases, it is to be expected that the shape of the distribution curve for the whole population will approach that obtained from adult samples at the present time. The ultimate variation for the world population occasioned by the differences in the concentration of strontium-90 in individual diets is already reflected in the skeletons of adults.

Four histograms are presented in Fig. 4. These cover all the more recent (1957–58) samples. They represent,

from top to bottom, (A) values for whole-body adult samples (80 skeletons) from New York City; (B) computed skeletal values from the measurement of individual adult bone samples from the northeastern United States (100 samples); (C) computed skeletal values from individual adult bone samples from rice-diet areas (Thailand, Taiwan, the Philippines, and Japan) (126 samples); and (D) computed skeletal values from individual adult bone samples from the whole world (838 samples).

Although the number of samples represented in histogram A (whole-body adult samples from New York City) was limited, the radiochemical analyses of the whole-body ash are more accurate than the skeletal values computed from analyses of single bones.

The histogram (B) of the skeletal burden computed from 100 analyses of individual bones from Boston and New York shows a larger spread than (A). This range is more apparent than real since the analyses of the single bones show an average counting error of about 30 percent, whereas the counting error on the whole-body ash averages about 10 percent for 1957–58 samples. Furthermore, the biological variation within a single bone and variation in the particular-bone–whole-skeleton ratio extend the range of the data. These factors may readily account for the difference in the values shown in histograms A and B; hence it may be concluded that the whole-body samples from New York City give the more accurate representation of the distribution of concentrations of strontium-90 in the population of the northeast United States and probably in most of the population living on a Western diet in the latitude band of 20° to 60°N.

Histograms B (northeastern United States) and C (rice-diet areas) may be compared directly, since they are both derived from single-bone analyses. It is clear that in the rice-diet areas the variation in strontium-90 concentration in the population is larger by a factor of about 2 than in the northeastern United States. This is probably a result of the more restricted flow of food in the Orient, the higher average contribution of vegetable calcium to the diet, and the greater variability of the vegetable-calcium–milk-calcium ratio in the diet in rice-diet areas. Also, the concentration of strontium-90 tends to vary to a much greater extent in vegetables than in milk (*12*).

Histogram D represents analyses of individual adult bones for the entire world for the period 1 July 1956 to 30 June 1958. Although the sampling is not proportional to the total population in each area, this curve provides the best empirical basis available on which to base an estimate of the world distribution of strontium-90 in man. The true distribution is no doubt narrower, as may be deduced from the comparison of histograms A and B above. Nevertheless, the curve given in histogram D is adopted in the discussion that follows, though it is acknowledged to be somewhat too broad. This distribution is clearly not normal, nor does it correspond closely to a lognormal pattern. A large fraction of the world's population gets most of its calcium from milk products, while the rest (largely Oriental) gets calcium from a variety of foods, cereals being the most important. That this distribution curve adequately represents the world adult population can be tested in a number of ways. It is useful to examine the range of strontium-90 concentration in milk in areas of Western culture, where milk products are the dominant source of calcium. Milk from a large variety of sources has now been analyzed (*11, 24*). These samples include a set of about fifty collected by this laboratory from untilled farms or from poor land in many parts of the United States. The highest concentration found in these samples was only about five times the mean for the United States. In the high-acidity–low-calcium areas in Kentucky, the highest concentrations in the milk samples were only twice the average for the United States

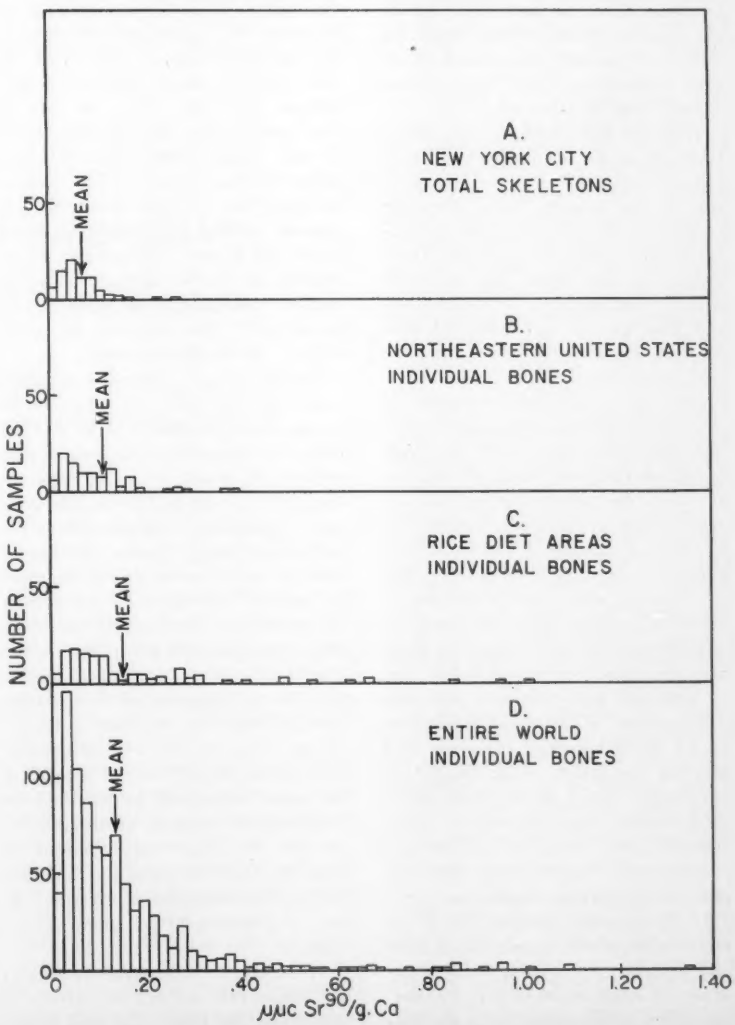

Fig. 4. Histograms showing comparative distributions of strontium-90 in bone.

and represented isolated farms. A restricted area in western North Dakota produces a milk that averages three to five times the mean for the United States. The people affected would be those who actually live on the farms that produce this milk, for if the milk is sold into the urban markets and combined with milk from other areas, the level of strontium-90 is quickly reduced. The population that might conceivably be affected is less than 0.1 percent of the population of the United States. Histogram D suggests that concentrations in foodstuffs at twice the mean level do not contribute greatly to the distribution curve.

Numerous food samples have been obtained from various parts of the world and analyzed for strontium-90. Levels in the foods which contribute significantly to the calcium in the diet do not vary by more than a factor of 2 or 3 from the mean in almost all cases. Again, the mixing of foodstuffs prevents individuals from maintaining a diet which is consistently high in strontium-90.

A special field study (*9*) was undertaken to sample the foods of the truly isolated Indian tribes of the uppermost part of the Amazon basin. Here the tropical conditions cause intensive leaching of the calcium from the soil. These people eat only what they can grow within a half mile or so of their village, and they have a very restricted diet. Most of their calcium comes from the yuca, which they prepare in various ways. Studies of a considerable number of sites showed the yuca to contain four to five times more strontium-90 per gram of calcium than components of the average world diet, despite the fact that the actual fallout in this area is considerably less than in latitudes 20° to 60°N. The number of people involved in this primitive situation, where there is virtually no inflow of food and where the mean annual temperature and rainfall are high, does not appear to exceed a few tens of thousands and constitutes less than 0.001 percent of the world population. In the world histogram (D) it is seen that the contribution to the distribution curve from these special groups whose diets contain concentrations of strontium-90 of five times the world average is quite small. It is concluded, therefore, that the empirical distribution curve (D) is reasonably representative of the entire adult world population in 1958 and probably of the whole world population at some future time if the concentration of strontium-90 in the diet becomes fairly constant with time.

A further critical problem is that of the proper method of extrapolating the distribution curve to the higher values. The curve cannot proceed indefinitely to the right for several reasons. Since the fallout is somewhat proportional to integrated rainfall for a given latitude band, and since the highest local rainfall does not exceed the world average by much more than a factor of 5, there is a limit set on the initial variation. Actually, the major agricultural areas have rainfall ranging only from about 20 to 60 inches per year, except in irrigated areas. With time, local variations become averaged out. The available calcium content of the soil can vary widely but, again, the variation is not large over most agricultural areas. The mixing of food completely obscures any local highs from the two factors discussed above so that, except for a few primitive areas, the high and low concentrations of strontium-90 in plants will not produce an equivalent range in man. Even the most primitive people tend to get their calcium from more than one type of food, and, further, they vary the source of their foods during their lifetime. Again, all these factors tend to equalize the diet. From all of the data at hand, it appears doubtful that any person in the world will have a sustained diet which exceeds the world average for strontium-90 concentration by as much as a factor of 20. This, then, sets the upper limit to the distribution curve.

Finally, it is of interest to consider what the distribution of strontium-90 among young children will be in 1966 when, it is estimated on the basis of tests to date, the maximum intake of strontium-90 in the diet will occur. The average concentration of strontium-90 in the skeletons of young children will then be about 4 μμc of strontium-90 per gram of calcium. The curve for the present distribution of strontium-90 in adults (Fig. 4, D) probably also represents the distribution for children of a specific age, since it comprehends the variation in world diet. On this basis it is predicted that at the time of maximum intake in the diet (1966), 10 percent of the young children will be found to have a skeletal concentration of strontium-90 of twice the mean, and 1 percent, of about five times the mean, and that none will have a concentration exceeding 80 μμc of strontium-90 per gram of calcium.

What hazards these levels present to the human race are still not certain. If suggestions, by Brues (*25*) and Finkel (*26*), that there is a threshold for the induction of leukemia or bone tumor are correct, no person will be injured by the strontium-90 that will be deposited by world-wide fallout from nuclear detonations that occurred up to the end of 1958. If the incidence of bone cancer and leukemia is linear down to zero radiation, as Lewis (*27*) and others have suggested, the number of cases can be readily computed for any future year (Figs. 3 and 4; Table 2).

Conclusions

1) In January of 1958 the average burden of strontium-90 in the skeletons of adults throughout the world was 0.19 μμc of strontium-90 per gram of calcium. This burden is independent of age above the age of 20. The concentrations of strontium-90 in bone differ less than the total fallout, as between the Northern and Southern hemispheres. This is attributable largely to the movement of food, particularly of powdered milk and wheat from the Northern Hemisphere into the Southern Hemisphere.

2) A theoretical curve for concentration of strontium-90 versus age has been constructed on the basis of findings on levels of strontium-90 in the diet for the past five years, data on bone growth reported by Mitchell *et al.*, and a discrimination factor of 4 for calcium against strontium from diet to bone. This curve corresponds closely to that for actual data from bone samples from the zone of Western culture of 20° to 60° N.

3) The average concentration of strontium-90 in the skeleton for all people in the world as of January 1958 was about 0.52 μμc of strontium-90 per gram of calcium.

4) On the basis of data on the strontium-90 in diet and bone, the world deposition, and the level of strontium-90 in the stratosphere at the end of 1958, curves have been drawn to show the anticipated concentrations of strontium-90 in the diet of individuals in the area of Western culture of 20° to 60°N and in newly deposited bone to the year A.D. 2000. It is estimated on the basis of these data that the maximum concentration in young children will occur about 1966.

5) A histogram representing 838 samples indicates the present distribution of strontium-90 in the adult population of the world. It is assumed that this reflects the actual spread of all age groups as a result of dietary variations throughout the world. The indicated distribution

may be somewhat wider than the actual distribution, due to analytical errors and biological variation in the ratio of single bone to whole skeleton. It is predicted that in 1966 the average young child in the world will have a skeletal concentration of strontium-90 of about 4 μμc of strontium-90 per gram of calcium; that 10 percent may have a concentration of 8 μμc; that 1 percent may have a level of 20 μμc; and that none will have a level exceeding 80 μμc of strontium-90 per gram of calcium.

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Isosterism and Competitive Phenomena in Drugs

A study of structure-activity relationships in agents acting upon autonomic effector cells

Daniel Bovet

Making use of the considerable means offered by organic synthesis, many investigators have directed their efforts to the field of therapeutics and have sought to lay the groundwork for a pharmaceutical chemistry or, better, for a chemical pharmacology. If such an ambitious program has not yet been fully realized, nevertheless, during the last five decades, one can notice the emergence of a few basic concepts whose usefulness continues to be confirmed. This is particularly true of the concepts of isosterism and of competition.

Numerous drugs were first derived from products of biological origin, particularly the alkaloids. The elucidation of their structure helped chemists to embark on syntheses of analogous compounds. In this respect cocaine, atropine, and morphine are good illustrative examples. The molecules synthesized according to their models exhibited clinically useful anesthetic properties, spasmolytic activity, or pronounced analgesic effects. In each case, chemical similarity produces in-some-way-related physiological properties.

Analogous observations have subsequently been gathered in many other fields, but it has also become evident that sometimes very different, even antagonistic, pharmacological properties may be found in chemically similar molecules.

Despite the fact that the concept of "antimetabolite" is based on rather old experiments, it was defined essentially in the field of "antivitamins"; the work of Woods (1940) and Fildes (1940) on the antisulfonamide component of yeast and its identification as *p*-aminobenzoic acid found a large acceptance. The idea that a compound structurally similar to one normally present in the organism is able to interfere with the function of this metabolite could be applied in many ways. Its success, especially in enzymology [where, for the first time, it was clearly formulated by Quastel (1925–1928)], in chemotherapy, in vitaminology, and in endocrinology, obviates a detailed discussion of the underlying physicochemical and biological principles. Instead, I would like to draw your attention to the importance of studies of competitive phenomena in pharmacodynamics, especially in the pharmacology of drugs of the autonomic nervous system. I would like to show how a very large part of therapeutical chemistry depends on the relations between many alkaloids or synthetic compounds and a few hormones, chemical transmitters, and products of tissue metabolism of rather simple chemical structure: epinephrine and norepinephrine, acetylcholine and propionylcholine, histamine, and 5-hydroxytryptamine (Table 1).

Dr. Bovet is head of the department of therapeutic chemistry at the Istituto Superiore di Sanità, Rome, Italy. This article is a translation of his Nobel lecture, presented 11 December 1957, when he was awarded the Nobel prize for medicine and physiology for 1957. It is reproduced here with the permission of the Nobel Foundation. We are indebted to Dr. Ernest Schoffeniels of the department of neurology, College of Physicians and Surgeons, Columbia University, for the translation.

The history of the research in this field is one of the most spectacular and successful chapters in the chemistry and physiology of the alkaloids and hormones. As far as transmitters of the sympathetic system are concerned, one may recall that the isolation of epinephrine by Takamine (1901) was preceded both by empiric application of ephedrine-rich *mahuang* by the Chinese, and by the fortuitous discovery of the properties of tetrahydronaphthylamine by Bamberger (1888). The exact significance of norepinephrine has been established only recently, by von Euler (1946).

In the field of parasympathomimetic agents, the observation of the properties of muscarine (1811) and the synthesis of acetylcholine (1866) preceded, by a century and a half century, respectively, the discovery of acetylcholine of Loewi (1921) and its isolation from tissues (1931). Histamine was synthesized (1907) shortly before its identification in the products of animal and plant origin and before Dale and Dudley (1910) began their well-known studies of its pharmacological properties.

The recent discovery of 5-hydroxytryptamine (Rapport, 1949) is the culmination of the work of Erspamer on enteramine isolated from enterochromaffin cells (1937–1952) and the work of Rapport, Green, and Page (1947–1948) on the vasoconstrictor factor of serum, serotonin.

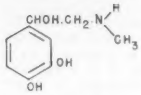
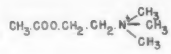
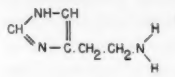
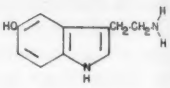
The relationship between epinephrine, tissue acetylcholine, and the nervous system was recognized early. In 1904, Elliot, struck by the similarity existing between the pharmacological action of epinephrine and the effect of stimulating the sympathetic system, proposed the hypothesis according to which epinephrine is released from sympathetic nerve endings and transmits the impulse from nerve cell to smooth muscle fiber.

Wieland in 1912 and Le Heux in 1919 tried to demonstrate that choline and acetylcholine were local hormones. Their hypothesis, we know, was successfully developed by Loewi, Dale, Cannon, and Bacq, whose experiments established the concept of chemical transmitters. The hypothesis of chemical transmission by acetylcholine first proposed for viscera innervated by the parasympathetic system was later extended by Dale, Feldberg, and Vogt (1936) to the neuromuscular junction. Recent investigations on the physiology of the end plate have, in sum, confirmed this mechanism. The reaction between acetylcholine and its receptor located at the postsynaptic membrane can now be integrated within the framework of electrophysiological findings, particularly those demonstrating electrical nonexcitability of this membrane and its great sensitivity to the transmitter (Kuffler, 1948; Castillo and Katz, 1956).

To turn now to substances antagonizing these various hormones and transmitters, models for the synthesis of adrenergic and cholinergic blocking agents were furnished by compounds of biological origin, such as ergotoxine, atropine, and curare. The antihistaminics were studied later and represent synthetic products of completely original design.

In practice, these drugs have been widely used in the symptomatic treatment of dysfunction of organs which are dependent on the activity of the autonomic nervous system: heart, blood vessels, bronchi, gastrointestinal tract, and uterus. The antagonists of epinephrine found their major application in the treatment of vascular disorders and hypertension. The antagonists of acetylcholine are used primarily as spasmolytic, mydriatic, and muscle-relaxing

Table 1. Drugs with a competitive action with respect to epinephrine, acetylcholine, histamine, and 5-hydroxytryptamine.

Adrenaline (noradrenaline)	Acetylcholine	Histamine	Hydroxytryptamine
			
Sympatholytic agents:	**Parasympatholytic agents:**	**Antihistaminics:**	**Antihydroxytryptamines**
Ergotamine	Atropine (spasmolytic agents)	929 F	
Yohimbine	Curares:	2339 R.P. (Antergen)	
Benzodioxane (933 F)	*d*-Tubocurarine	Pyrilamine	
Dibenamine	Gallamine	Diphenhydramine	
Phentolamine	Decamethonium	Antazoline	
	Succinylcholine	Promethazine	
	Ganglioplegic agent:		
	Hexamethonium		
	Central ganglioplegic agents:		
	Antiparkinson agents		
	Antiphobic agents		

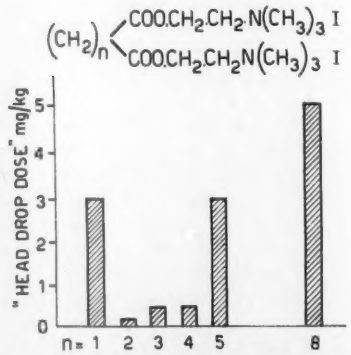
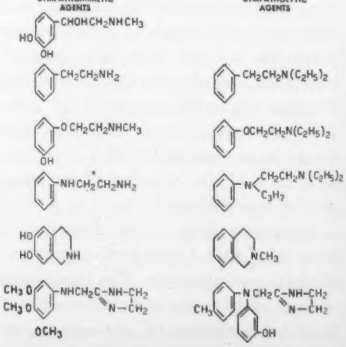


Fig. 1. Curarizing effect of choline esters and dicarboxylic aliphate acids with normal chains. Curarizing activity was established in rabbits by measuring the "head drop" dose of the various compounds given intravenously. Curarizing activity reaches a maximum with succinylcholine and decreases with higher homologues of the series. [Bovet, Bovet-Nitti, Guarino, Longo, and Marotta, 1939]

Table 2. Structural relations between sympathomimetic and sympatholytic agents. [Raymond-Hamet, 1937; Bovet and Simon, 1936; Druey, 1936; Bovet, de Lestrange, and Fourneau, 1942; de Beer and Fassett, 1938; Hartmann and Isler, 1939; Gross, Tripod, and Meier, 1951]



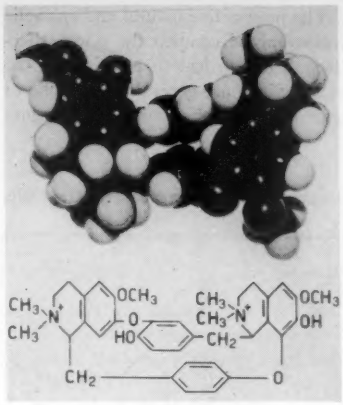
agents. The antihistaminics are most useful in the treatment of urticaria, rhinitis, asthma, and other allergic diseases.

For specific illustrations, I shall use examples from three different pharmacological groups. For the epinephrine group, I will consider ergotamine; for the antiacetylcholine group, curare; and for histamine, I will consider the synthetic antihistaminics.

Synthetic Sympatholytic and Ergotamine-Like Compounds

Sympatholytic drugs form a group characterized by common pharmacological properties. They act as competitors—or blocking agents, in Anglo-Saxon terminology—by opposing the effects of epinephrine and norepinephrine. Most characteristically, they block the hypertension and vasoconstriction produced by epinephrine.

As is often the case, various drugs of this class were introduced empirically into therapeutics long before their pharmacological actions were established. As long ago as 1909, Froelich noticed that animals pretreated with small doses of the dextrorotatory isomer of epinephrine became resistant to the effects of the natural isomer. Today we explain this observation as resulting from a partial block of the receptors by a pharmacologically much less active enantiomorph of the compound. Later Loewe (1927), Külz (1936), and Raymond-Hamet (1937) described N-alkyl derivatives of phenylethylamine with sympatholytic properties; analogous properties were described in the phenoxyethylamine series (Anan, 1930; Levy and Ditz, 1933; Bovet and Maderni, 1933; Bovet, Simon and Druey, 1937), the phenylethylenediamine series (Bovet, de Lestrange, and J. P. Fourneau, 1942), the isoquinoline series (Hjort, de Beer and Fassett, 1938), and the phenylaminoethylimidazoline series (Meier and Müller, 1939; Hartmann and Isler, 1939). In each of these groups the structural similarities between the antagonistic molecules with either sympathomimetic or sympatholytic properties are evident (Table 2); the degree of substitution on the amine, the suppression or displacement of the phenolic function, the closing of a ring, are sufficient to reverse the pharmacological action. It is very important to notice that while the distance between the amine function and the aromatic ring remains constant in both sympathomimetic and sympatholytic agents, the inhibitory molecule has always, in con-



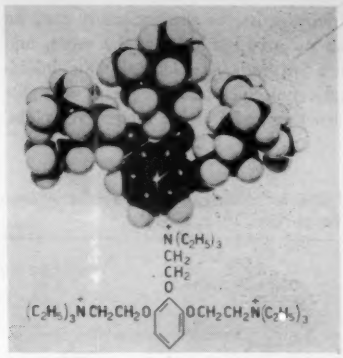


Fig. 2. Pachycurares. (Left) d-Tubocurarine; (above) gallamine.

Table 3. Classification of the main groups of sympathomimetic and sympatholytic agents.

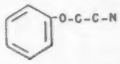
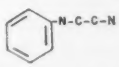
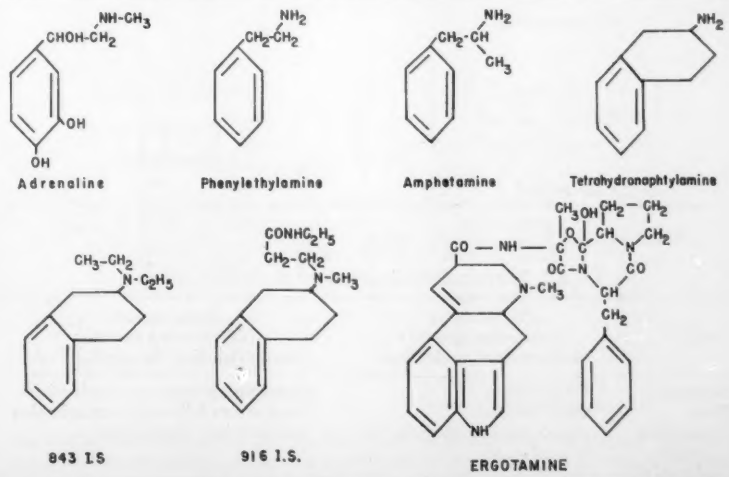
Phenylethylamines	 Phenoxyethylamines	 Phenylethylene diamines
	Sympathomimetic agents	
Epinephrine Phenylethylamines and their phenolic derivatives	Phenolic derivatives of phenoxyethylamine	Phenylethylenediamine and its phenolic derivatives
	Sympatholytic agents (aromatic series)	
N-Diethylphenylethylamine	N-Diethylphenoxy-ethylamine	N-Diethyl-N'-propyl-N'-phenylethylenediamine
Dibenamine Tetrahydronaphthylamines, N-substituted	Dibenzyline	
	Sympatholytic agents (heterocyclic series)	
N-Methyltetrahydro-isoquinoline Benzylimidazoline	Benzodioxane: Prosympal Piperoxan	Phenylpiperazine Phentolamine
	Sympatholytic alkaloids	
Ergot alkaloids		Yohimbine

Table 4. Structural relations between sympathomimetic and sympatholytic agents: from epinephrine to ergotamine. [Marini-Bettolo, Chiavarelli and Landi, Vittory, 1950–1953; Bovet, Bovet-Nitti, Virno, Longo, Marotta, and Sollero, 1953]



tradistinction to the excitatory one, an amino group substituted by more, and heavier, radicals. Generally the inhibitory molecules also have a more stable structure and a higher molecular weight.

The most active natural and synthetic sympatholytic compounds, whose effectiveness is sufficient to permit their use in the clinic, are generally polycyclic or heterocyclic, with structures analogous to the above-mentioned compounds despite their complexity. Benzylimidazoline (Meier and Müller, 1939) and dibenamine (Nickerson and Goodman, 1947) are related to the phenylethylamines; the aminomethyl-benzodioxanes (Fourneau and Bovet, 1933), to the phenoxyethylamines; and phentolamine (Gross, Tripod, and Meier, 1951) to phenylethylenediamine derivatives (Table 3).

Studies conducted at the Istituto Superiore di Sanità by Marini-Bettolo and Chiavarelli, on the chemical aspects, and by F. Bovet-Nitti, Longo, Marotta, and Guarino on the pharmacological aspects, illustrate the usefulness of the concepts of isosterism and of competition in this kind of investigation.

When the isolation and structural determination of the ergot alkaloids was achieved—researches for which we are largely indebted to Stoll and Jacobs—much work was done to prepare derivatives by partial or total synthesis; thus, dehydrogenated derivatives (Rothlin, 1947) and oxytocic derivatives closely related to ergometrine (Rothlin, 1947) were prepared, and the diethylamide of lysergic acid with hallucinogenic properties was discovered (Stoll). Since we proposed to investigate the structure-activity relationships of ergotamine, we used as our working hypothesis the concept relating structure to antagonistic action.

At first sight, the structure of the ergot alkaloids seems to be very different from that of epinephrine or of sympathomimetic derivatives of the phenylethylamine series. Nevertheless, since the skeleton of β-tetrahydronaphthylamine (2-aminotetralin) can be recognized in the structure of lysergic acid, we decided to study compounds of this group (Table 4).

Pharmacological tests with derivatives of relatively simple structure demonstrated the sympatholytic activity of 2-diethylaminotetralin (843 I.S.). Studies with more complex molecules, in particular the amide and amine derivatives of 2-tetralin, are a new step in the attempt to reproduce the essential portion of the lysergic acid skeleton. Using molecules of increasing complexity, one may go by successive stages from phenylethylamine to tetrahydronaphthylamine or to N-(2-tetralyl)-N-methyl-N′-ethyl-β-alaninamide (916 I.S.) and the ergot alkaloids, with a resulting progressive diminution at each stage of sympathomimetic properties and the appearance of sympatholytic properties.

Oxytocic activity was observed in a large number of synthetic derivatives,

Table 5. Investigations of synthetic oxytocic agents, derived from phenylglycinamide. [Bovet-Nitti, 1952, 1954]

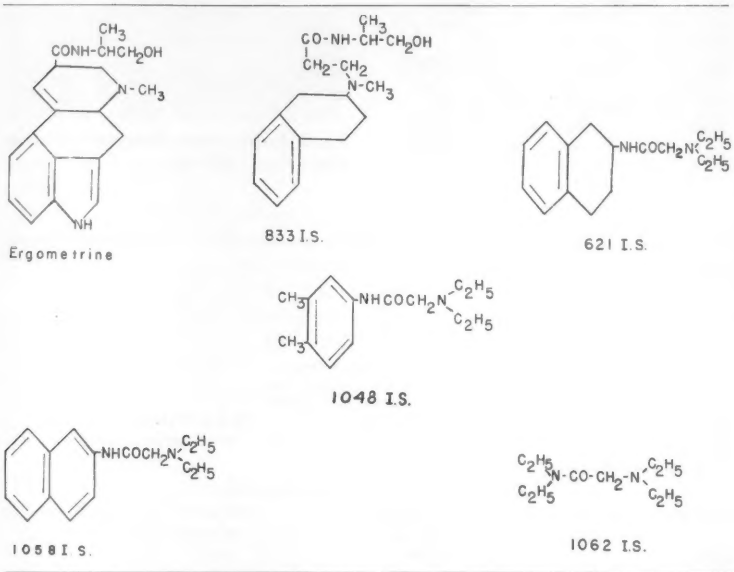


Table 6. Natural and synthetic curares: *d*-tubocurarine (King, 1935; Wintersteiner and Dutcher, 1943); 3381 R.P. (Bovet, Courvoisier, Duclos, and Horclois, 1946); gallamine (Bovet, Depierre, and de Lestrange, 1947); succinylcholine (Bovet, Bovet-Nitti, Longo, and Marotta, 1949; Fusco, Palazzo, Chiavarelli, and Knüsli, 1949).

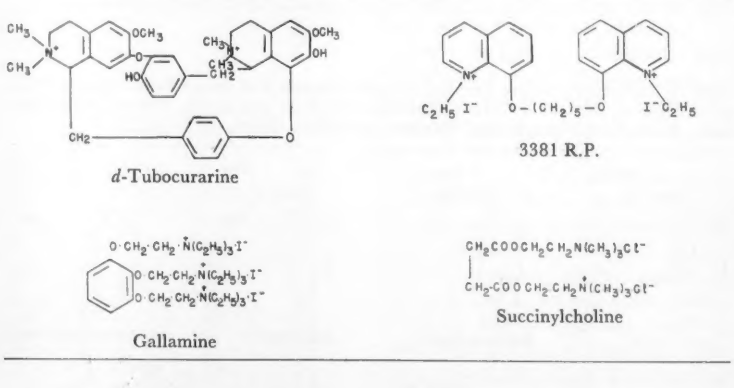


Table 7. Pharmacodynamic properties of synthetic curares.

Subject	Pachycurares (competing agents): tubocurarine, gallamine	Leptocurares (depolarizing agents): succinylcholine, decamethonium
Mammals	Curarization	Curarization (muscular fibrillation)
Birds	Curarization	Contracture followed by curarization
Amphibians (*rectus abdominis*)	Antagonism to acetylcholine	Acetylcholinic contracture

and this class of compounds seems very broad compared to that of adrenolytic substances (Table 5). In the course of experiments performed on rabbit uterus, isolated or *in situ*, several derivatives of aminotetralin and of aniline and even some aliphatic compounds showed strong activity. We may single out such examples as N,N-diethyl-N′-(2-tetralyl)glycinamide (621 I.S.); N,N-diethyl-N′-3-4-dimethylphenylglycinamide (1048 I.S.); and N,N,N′,N′tetraethylglycinamide (1062 I.S.) (Bovet-Nitti, 1953).

The main difficulty, apparently encountered also by other investigators, was the lack of parallelism between effects observed in laboratory animals and in man. Generally speaking, a satisfactory solution to the problem of synthetic oxytocics has not yet been reached, and the question is still under study.

Antagonists of Acetylcholine: Synthetic Curares

The problem of competitive agents that antagonize acetylcholine activity is rather complex, due to the multiple functions of this transmitter. Acetylcholine is the chemical transmitter in viscera innervated by the parasympathetic system; it has a role at the neuromuscular junction, and it is liberated in ganglia during the passage of a nerve impulse. A surprising fact, which has been profitably exploited in pharmacological investigations of competitive agents, is that compounds antagonizing acetylcholine differ according to the site of action of the local hormone. Thus, atropine and benzoylcholine neutralize the muscarinic effects of acetylcholine on cardiac receptors, on the intestine, or on secretions; tetraethylammonium iodide or hexamethonium block the nicotinic action of acetylcholine on sympathetic and parasympathetic ganglia. Finally, curares are specific antagonists of acetylcholine in striated muscle. With respect to the structure of antagonists, synthetic curares furnish us with a succession of examples comparable to those we have reviewed in the sympatholytic group. These investigations were begun in 1946, after King's elucidation, in 1935, of the structure of one of the physiologically active constituents of Amazonian curares, and after the introduction by Griffith and Cullen in 1942 of the chemically pure alkaloid as an adjuvant in anethesia.

d-Tubocurarine, which is extracted from a menispermum, *Chondodendron tomentosum*, is found in curares prepared by the natives of the Upper Amazon. It is an alkaloid of the group bis(benzyltetrahydroisoquinoline), whose molecule has two quaternary ammonium functions.

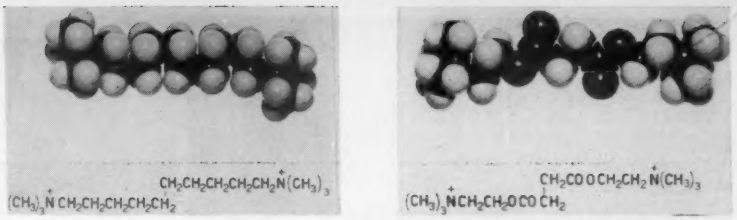


Fig. 3. Leptocurares. (Left) Decamethonium; (right) succinylcholine.

In research done with our colleagues, Viaud, Horclois, and de Lestrange, we first looked for molecules structurally close to the selected model. By successive transformations, we were able to synthesize relatively simple derivatives with analogous properties (Table 6). From a series of new compounds with two quinolinic rings bearing quaternary ammonium functions, we first selected the diiodoethylate of 8′,8″-diquinolyloxy-1,5-pentane (3381 R.P.). This was the first synthetic compound with curare-like action in mammals showing a specificity comparable to that of natural alkaloids isolated from curare (1946).

It was then found that aminophenol derivatives which have neither quinoline nor isoquinoline rings had similar activity, and this was also true for polyphenol ethers and aromatic esters. The latest investigations on the path to ultimate simplification are concerned with the activity of aliphatic derivatives.

In England, Barlow and Ing and Paton and Zaimis (1948) reported extremely interesting observations on the curare-like effect of decamethylene-ω-bis-trimethylammonium hydrate (decamethonium). In our Laboratory of Therapeutical Chemistry at the Istituto Superiore di Sanità, the curare-like action of succinylcholine was first recognized. This compound was synthesized by Hunt in 1911.

The number and variety of compounds with curare-like action, the relative simplicity of their mode of action, and the possibility of precise pharmacological assay permitted a careful study of structure-activity relationships of synthetic curares.

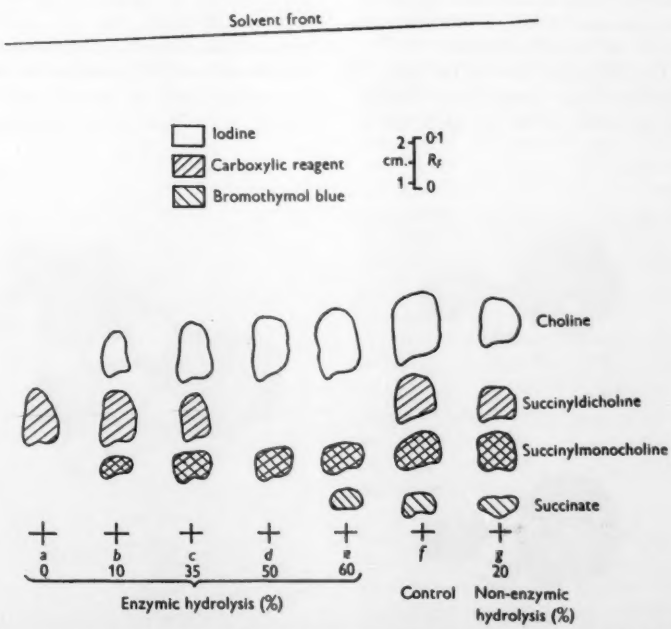


Fig. 4. Chromatograms of (*a* to *e*) succinylcholine at various stages of enzymic hydrolysis; (*f*) a mixture of succinylcholine and its products of hydrolysis; (*g*) 0.1 mg of succinylcholine after nonenzymic hydrolysis. [Whittaker and Wijesundera, 1952]

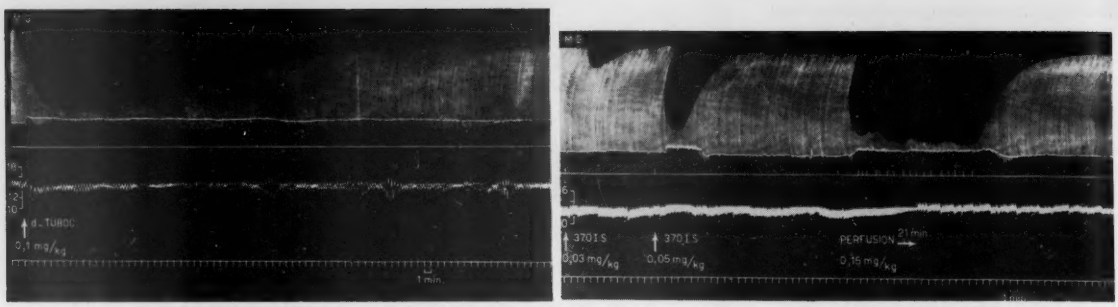


Fig. 5. Comparison between curarizing effects of *d*-tubocurarine (left) and of succinylcholine (right) given intravenously as a single injection or by continuous perfusion on the dog, under chloralose anesthesia. (First line) Contraction of the gastrocnemius muscle following the rhythmic stimulation of the sciatic nerve; (second line) control of the speed of injection; (third line) blood pressure. The record shows clearly the difference between the duration of neuromuscular paralysis following a single injection of succinylcholine (370 I.S., 0.05 mg/kg) and of *d*-tubocurarine (0.1 mg/kg). Also, on comparing the effect of a single injection of *d*-tubocurarine with continuous perfusion of succinylcholine (initial injection of 0.05 mg followed by repeated injection of 0.0062 mg at each signal), one sees that; for the duration of subtotal and reasonably uniform curarization (about 80 percent, for 20 minutes), the reversibility of the effect is quick (about 10 minutes) after infusion of succinylcholine while it is slowly progressive (about 50 minutes) after injection of *d*-tubocurarine. [Reuse, 1953]

I will mention only two important factors which influence the activity of bis-quaternary derivatives: the distance between the quaternary ammonium groups and the massiveness of the molecule.

The first factor is illustrated by comparison of polymethylene-bis-trimethylammonium derivatives (Barlow and Ing; Paton and Zaimis, 1948) as well as of aliphatic diesters of choline (Bovet, Bovet-Nitti, Guarino, Longo and Marotta, 1949) (Fig. 1).

Careful pharmacological study showed that the action of new synthetic derivatives was sometimes quite different from that of the natural alkaloids.

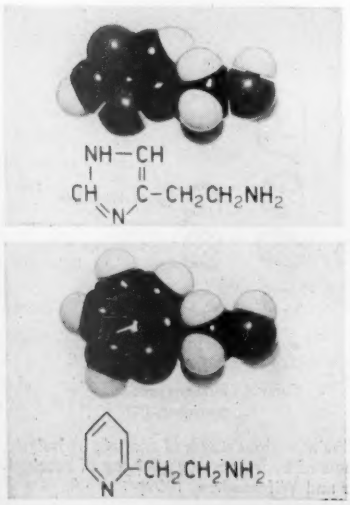
The differences between the action of decamethonium iodide and succinylcholine iodide on the one hand and the action of *d*-tubocurarine and of the triiodethylate of gallamine on the other were carefully studied by Paton and Zaimis, Brown and Dias and in our own laboratory. The British authors have proposed calling these two groups depolarizing agents and competitive curares. We proposed designating decamethonium and succinylcholine as leptocurares, and tubocurarine and gallamine as pachycurares (Figs. 2 and 3; Table 7). The advantage of our nomenclature lies in the fact that it does not presume the mechanism of action. The main difference between the pharmacodynamic effects produced by the two types of curares is determined by the responses of amphibian and bird muscles. In birds, the pachycurares are typical curarizing agents, while leptocurares induce contracture that is followed by curarization.

In mammals the differences between the two groups are less sharp. The responses of muscle from different species or of different muscles from a single species are not always comparable. Also, intermediary steps seem to exist between depolarization and curare competition. The distinction between the groups, though relative with respect to the mechanism of action and the type of preparation used, are, nevertheless, useful if we want to compare relations between chemical structure and pharmacological activity.

Clinically, the most important factor in classification of curares is duration of effect. In this respect, the introduction of a short-acting curare, particularly succinylcholine, is an important step forward. The relative ease with which succinylcholine is hydrolyzed by pseudocholinesterase and the very low toxicity of the products choline and succinic acid account for the brevity of action and the remarkable tolerance of the organism for this curare (Fig. 4; Table 8).

The first clinical observations concerning short-acting curares were published by Valdoni (1949) and Scurr (1951) and deal with suxethonium. The introduction of succinylcholine into anesthesiology was first proposed in Sweden, by Thesleff (1951), Holmberg and Thesleff (1951), Tammelin and Löw (1951), and von Dardel (1951), and in Austria, by Brücke *et al.* (1951), Mayrhofer and Hassfurther (1951), and Holzer (1951).

In the light of these various investigations, one may today recognize two methods of using succinylcholine: single injection when very short action is required (as for endoscopy or electro-



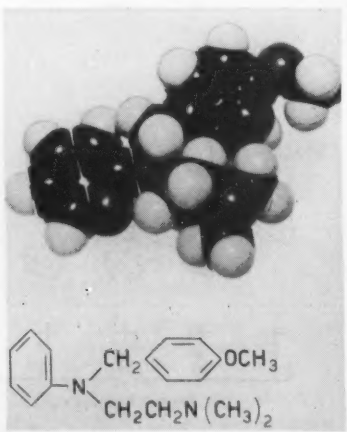
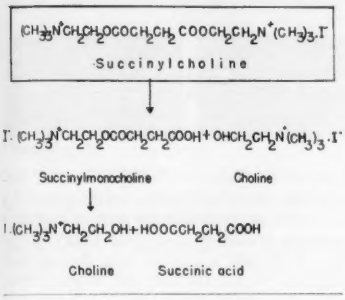


Fig. 6. (Left, top) Histamine; (left, bottom) pyridylethylamine; (above) pyrilamine.

Table 8. Hydrolytic products of succinylcholine.



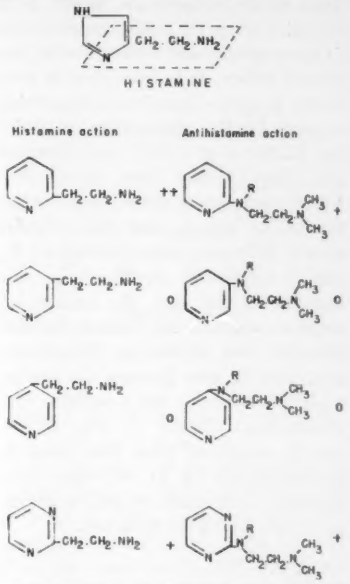
shock) or continuous infusion in surgical procedures of long duration.

Two recordings from a study in our laboratory demonstrate results obtained with the two types of application. They show the superiority of continuous infusion of short-acting curares over the classical technique (Fig. 5).

Antihistamines

The last example I will use to illustrate the concept of competition is concerned with compounds that antagonize the third local hormone, histamine. This is a particularly rich field since the usefulness of these compounds has stimulated a great many investigations within a very few years. In 1937, in Fourneau's laboratory, we began—A. M. Staub and I—to look for compounds antagonistic to histamine. Considering the number of features that histamine, acetylcholine, and epinephrine have in common, we looked for antagonism comparable to that exhibited by sympatholytic compounds toward epinephrine and by parasympatholytic compounds toward acetylcholine. We obtained the first positive results in 1939 with thymoxyethyldiethylamine (929 F). Our experimental work was then directed toward defining criteria for antihistaminic activity. Staub (1939) extended her observations to phenylethylenediamine derivatives. In 1942, the syntheses by Mosnier, the pharmacodynamic studies of Halpern, and the first therapeutic results of Cuilleret, Thiers, Gaté, Celice, Perrault, Decourt, and Durel with dimethylaminoethylbenzylaniline, or Antergan, definitively established interest in compounds of this group. The role played by histamine in many allergic affections assures a broad area of clinical application of these compounds. After the pioneers (Maderni, de Lestrange, and Benoit in Fourneau's laboratory in Paris; Viaud, Horclois, Mosnier, and Charpentier in French industry; Hartman and Hofman in Switzerland; Rieveschl, Scholz, Huttrer, and Roblin in the United States; Cavallini in Italy), about 500 chemists synthesized, in less than ten years, more than 5000 compounds in the antihistaminic group.

Table 10. Structural relations between histamine and antihistamines. [Walter, Hunt, and Fosbinder, 1941; Nieman and Hays, 1942; Bovet and Walthert, 1943]



Pharmacologists were easily able to recognize the competitive nature of the antagonism exerted by these antihistaminics toward histamine. Chemists, however, could not perceive any relation between the structure of antihistaminics and histamine which logically might explain such activity, nor could they find a relationship among the various active compounds. It was therefore impossible to escape the conclusion that most of the results were rather empirical.

From the pharmacological viewpoint, it was possible to distinguish three groups of substances (see Table 9) with antihistaminic action and relate them to (i) the sympatholytic group; (ii) the parasympatholytic-sympatholytic group; and (iii) histamine itself.

To the first group belong the phenolic esters (929 F) and the phenylethylenediamine derivatives (1571 F) studied at the Pasteur Institute, Halpern's Antergan, and the antazoline of Meier and Bucher. The compounds of the second group, from a chemical point of view, have more homogeneous structures, in

Table 9. Principal groups of synthetic antihistaminics: 929 F (Bovet and Staub, 1937); Antergan (Halpern, 1942); antazoline (Meier and Bucher, 1946); diphenhydramine (Loew, Kaiser, and Moore, 1945); promethazine (Halpern and Ducrot, 1946); chlorphenamine (Tislow, La Belle, *et al.*, 1949); pyrilamine (Bovet, Horclois, Walther, and Fournel, 1944); tripelennamine (Mayer, Huttrer, and Scholz, 1945); thonzylamine (Reinhard and Scudi, 1947).

Antihistaminics related to:		
Sympatholytic agents	Spasmolytic agents	Histamine
929 F	Diphenhydramine	Pyrilamine
Antergan	Promethazine	Tripelennamine
Antazoline	Chlorphenamine	Thonzylamine

common with atropine-like drugs and other spasmolytics; some of these are, in fact, spasmolytic as well as antihistaminic (diphenhydramine). In derivatives of α-aminopyridine, which form the third group, the antihistaminic action is more specific and almost free of secondary effects. It is interesting to note in this group the isosteric reactions which account for the pharmacological activity. Walter *et al.* (1941) and Niemann and Hays (1942) have shown that α-pyridylethylamine derivatives have histamine-like activity, and that a fundamental difference exists between α-, β-, and γ-substituted pyridines in this respect. In this case, the analogy of structure which is not evident between histamine and pyrilamine (Neo-Antergan) may be seen between the groups α-pyridylethylamine and α-pyridine ethylenediamine (Table 10, Fig. 6). A typical compound from this group is pyrilamine (see Fig. 7), but many other synthetic compounds of similar design have also proved to be active.

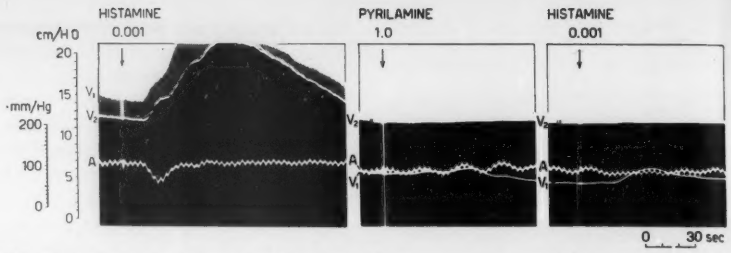


Fig. 7. Antagonistic action of pyrilamine with respect to the vasodilating effects of histamine in cerebral circulation. The subject was a dog under chloralose anesthesia. (*A*) Blood pressure, femoral artery (mm-Hg); (V_1) pressure recorded through a catheter introduced in a centrifugal direction into the external maxillary vein (mm-H_2O); (V_2) pressure in the internal maxillary vein (mm-H_2O). Injection was made into the saphenous vein; dosages are given in milligrams per kilogram. [Virno, Gertner and Bovet, 1956]

Central Action of Transmitters

The compounds considered so far do not exhaust the ranks of competitive agents. Pharmacologists are to some extent *les enfants terribles* of physiology. They did not wait for the battle of the neuromuscular junction to be won before engaging in a more difficult encounter. They proposed that the available evidence suggested the action of a chemical transmitter in the central nervous system, exactly as in the autonomic nervous system.

Analyzing the collective results from various laboratories, Feldberg (1950) concluded that the theory ascribing a transmitter role to acetylcholine in the central nervous system was the only one able to offer convincing and satisfactory interpretations. Even if intervention of noncholinergic chemical transmitters in the central nervous system is not excluded, we must admit that our knowledge about the probable roles of norepinephrine, epinephrine, histamine, and 5-hydroxytryptamine is still quite incomplete.

The physiological role of the reticular formation in the brain stem has been clearly defined by Moruzzi and Magoun (1949). In the last few years, a considerable number of investigations have shown that compounds affecting the autonomic nervous system also affected this formation.

Paradoxically enough, cholinergic as well as adrenergic substances affect the electrical activity of the cortex in the same way that direct electrical stimulation of the reticular formation does. Under well-defined experimental conditions, acetylcholine (Bonnet and Bremer, 1937) and epinephrine itself (Bonvallet, Dell, and Hietzel, 1954) provoke a transient activation in the electroencephalogram. The administration of either an anticholinesterase (eserine, diisopropyl fluorophosphate) or of amphetamine (Bradley and Elkes, 1953) produces an intense and prolonged desynchronization.

From a strictly pharmacological viewpoint, the major interest in this type of investigation stems from the similarity in observed antagonisms between various groups of drugs in the central nervous system and in viscera innervated by the autonomic nervous system.

As early as 1947 we suggested that in extrapyramidal syndromes some relation might exist between the central, "antiparkinson," effect of certain tertiary amines and their ganglioplegic properties in peripheral ganglia (Sigwald and Bovet; Dumont; 1947).

"Antiparkinson" drugs form a relatively homogeneous group comprising diethazine (Diparcol), isothazine (Parsidol), caramiphen (Parpanit), and trihexyphenidyl (Artane), as well as some antihistaminics (diphenhydramine and promethazine).

Electroencephalographic studies (Fig. 8) have shown that three groups of compounds produce an electroencephalogram similar to that recorded during sleep: the parasympatholytics (scopolamine and atropine), the central ganglioplegic or "antiparkinson" drugs (Table 11), and the neuroleptics (chlorproma-

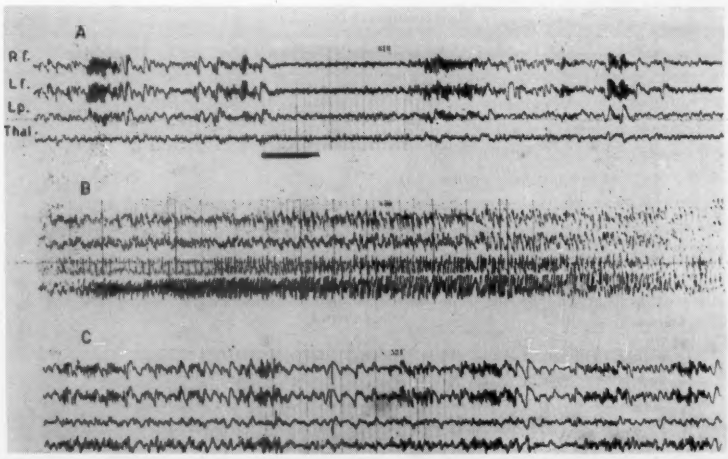


Fig. 8. Antagonistic action of diethazine against convulsive patterns caused by nicotine on the electroencephalogram of curarized rabbit. (A) Blocking reaction after acoustic stimulation (black line). (B) Convulsive seizure by nicotine (2 mg/kg) in normal animal. (C) After injection of diethazine (5 mg/kg) a second injection of nicotine no longer produced the electrical changes observed previously, and the acoustic stimulus fails to produce the blocking reaction. [Longo and Bovet, 1952]

zine, reserpine). These also antagonize the cortical reaction elicited by external stimuli (stress) or by desynchronizing agents (eserine and amphetamine) (Bovet and Longo, 1956). The effect of such synchronizing agents may, as a first approximation, be localized in the reticular formation and thus be comparable to the importance of chemical transmitters at this level.

Many observations suggest that specific receptors for epinephrine, acetylcholine, and histamine are specific proteins with a structural configuration complementary to that of the transmitter. This concept was first proposed by Fischer, who illustrated it with the now famous model of key and lock. This mechanism has been invoked to explain observations in physiological and chemical studies of taste and smell. Recently, Landsteiner and Pauling applied this idea of "complementary configuration" in the field of immunological reactions.

At this point it would not be possible to consider the various aspects of reactions between chemical transmitters, inhibitors, and receptor proteins without taking more space than is available.

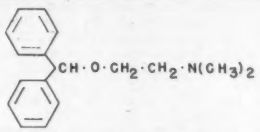
The particularly simple case of binding acetylcholine with cholinesterase has been studied by Nachmansohn (1953–1954) and Wilson (1954). They consider acetylcholine to be attached at two points, one electronegative and the other electropositive, and have drawn valid conclusions with respect not only to various anticholinesterases but also to a new group of drugs that reactivate the phosphorylated enzyme.

If I cared to develop the extensive areas covered in this article I could include other topics and point out that different groups of compounds affect the metabolism of mediators because they are precursors or because they inhibit synthesis, slow down or accelerate liberation, or interfere with destruction. In every phase, investigations have been successful and the results appear to be very promising.

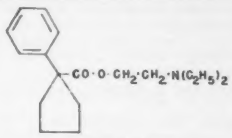
Conclusion

The composite picture I have tried to present, at the risk of relating many already well-known facts, appears, despite inevitable gaps, very certain. If, in concluding, we rapidly retrace our path, we will see that in covering the vast field of pharmacology, the structures of a small group of remarkably simple biogenic amines have led us, like the thread of Ariadne, through the labyrinth of very diverse physiological actions and chemical structures.

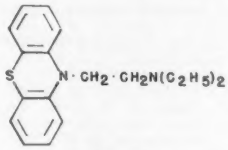
Table 11. Central ganglioplegic agents: diphenhydramine (Loew, Kaiser, and Moore, 1945); diethazine (Sigwald, Bovet, and Dumont, 1946; Bovet, Fournel, and Charpentier, 1947); caramiphen (Domenjoz, 1946; Grünthal, 1946); trihexyphenidyl (Doshay and Constable, 1949).



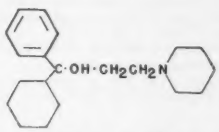
Diphenhydramine (Benadryl)



Caramiphen



Diethazine



Trihexyphenidyl

It has been said that the art of the orator is to speak about what he knows and to hide his ignorance. I do not feel any need to resort to such an artifice in presenting the current picture of the chemical pharmacology, because it is, in final analysis, only a kind of "natural history" and classification of organic molecules.

I would say that the results obtained so far give rise to optimism because they let us catch a glimpse of the pharmacology to come as a well-ordered and well-defined science in which foods, drugs, and poisons will be integrated in the metabolism of the simplest constituents of living matter.

Finally, in recalling the great names associated with studies of the pharmacological agents that made it possible for us to reach our present level, I can only speak with emotion of all those who preceded me, particularly of my teacher, Ernest Fourneau, who wrote such a great and glorious chapter of therapeutic chemistry and whose name will forever be written in the history of this science.

My feelings are sincerely divided between the immense pleasure I feel at the honor which is bestowed on me and my sense of inadequacy at being unable to repay my teachers and colleagues all that I owe them. This feeling is the more vivid because therapeutic chemistry is a very young science that has developed amazingly during the past half century; perhaps in no other domain does the part played by each individual appear so clearly and with such continuity as in our studies, where every formula bears a name always well-known and sometimes very close to us.

The future of pharmacodynamics is, nevertheless, so rich and promising, and it bears so many theoretical and practical possibilities, that I cherish the hope that my future work will justify not only the marvellous distinction I have received today but also the confidence and the friendship of my teachers and colleagues, whose works cannot be separated from those I pursue with confidence, enthusiasm, and love.

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Manuel Luz Roxas, Agricultural Chemist

Manuel Luz Roxas was one of the foremost scientists in the Philippines. His valuable services to the University of the Philippines as a teacher of chemistry in the College of Agriculture and the important role he played in the creation and organization of the National Research Council of the Philippines will be long remembered.

Almost immediately after Dr. Roxas' graduation from the University of the Philippines in 1911, with a B.S. degree in Agriculture, his first research work appeared in the *Philippine Agriculturist and Forester* under the title "The pandan industry in Majayjay." This was soon followed by three other articles in the same journal: "The cultivation of coconut," "The effect of some stimulant upon rice," and "The coffee industry in the island of Luzon." Dr. Roxas pursued further studies in his chosen field and in 1913 obtained his M.S. degree at the University of the Philippines, where he then served as instructor in chemistry until he was appointed a university fellow to the United States. Evidently this appointment was in recognition of his unusual endowment with the "divine spark" to perform research. He enrolled in the University of Wisconsin and received his Ph.D. there in 1916.

Manuel Luz Roxas

On his return to the Philippines, Dr. Roxas resumed his position in the College of Agriculture in the University of the Philippines, where he was later appointed assistant professor, then professor of chemistry, and ultimately, professor emeritus of agricultural organic chemistry. He was also named Distinguished Alumnus of the University of the Philippines in 1932 for achievement in scientific research. All these deserved recognitions were due to his active labor in the field of research, especially in agricultural chemistry and food technology; his 95 scientific papers were published in various journals, including the *Philippine Agriculturist and Forester*, the *Journal of Biological Chemistry*, *Sugar News*, and the *Journal of the Philippine Islands Medical Association*.

The National Research Council of the Philippines owes its origin to the leadership of Dr. Roxas. He headed a committee that worked continuously in preparing the draft of the bill for its creation which was introduced in the House of Representatives. With the support of Manuel L. Quezon as Senate President and other leaders of the Philippine Legislature, and the cooperation of the then Governor General Frank Murphy, Act 4120 creating a National Research Council for the promotion of research along scientific lines was approved on 8 December 1933. Elected as first chairman of the National Research Council, Dr. Roxas did a great deal in the organization of the different divisions integrating the Executive Committee of the council. For his distinguished and outstanding contributions in scientific research in the Philippines, Dr. Roxas may well be considered the "father of the National Research Council of the Philippines."

Manuel Luz Roxas was a man of sterling character, a good Filipino and patriot, simple and humble; all these qualities enhanced his merit as a true man of science. Our country can never repay what it owes him for his scientific labor and devotion to research.

ANTONIO G. SISON
National Research Council of the Philippines, Quezon City

News of Science

Variety of Opinions on Department of Science Bill Given by Witnesses during 2-Day Senate Hearings

During Senate hearings on a department of science bill, witnesses testified that such a department is necessary if the federal government is to increase the flow of career scientists into its various scientific agencies. Speakers opposed to the bill held that science would become isolated from public affairs if it were centralized in one department.

These conflicting opinions were expressed last month at hearings held before a Senate subcommittee gathering information on the Department of Science and Technology bill now going through the legislative process of the Congress. The bill, S. 676, would transfer the National Science Foundation, the Atomic Energy Commission, the National Aeronautics and Space Administration, and the National Bureau of Standards, and certain functions of the Smithsonian Institution to a new executive department which would rank equally with the existing departments, such as State, Commerce, and Defense.

Pro and Con

The views of the witnesses ranged from qualified support to full rejection. Alden Emery, who is executive secretary of the American Chemical Society, and Wallace Brode, science adviser to the Secretary of State and retiring president of the board of the AAAS, stressed the point that a department of science would be of great value in drawing career scientists to government. Emery said: "For government research to flourish, it must be able to attract and hold outstanding scientists who will be willing to make government service a lifetime career. Men of this type are most likely to be interested if they can see the possibility of promotion to positions of high responsibility without having to leave the scientific field. Such positions can be provided only by grouping enough scientific activities together to build a sizable organization." Brode, who spoke in his capacity as an officer of the AAAS, said that "recognition of science as a basic entity" in our governmental organization would strengthen the status of career scientists in government.

Opposition to the general idea of a department of science was voiced by a number of witnesses, including A. Hunter Dupree, historian, and Lewis Strauss, Secretary of Commerce. The position of the opponents was that science does not, by its nature, lend itself to centralized organization. Both Dupree and Strauss pointed to the pervasiveness of science. Dupree said that science, as a policy area in the Government, must be compared "not with agriculture or commerce, but with economics or security. It is a pervasive thing, which had, even by the 1880's, penetrated so many different areas of government activity that a joint congressional committee found it impossible to define a separate area for a department of science." Strauss, citing 20 years of work with scientists in government and a period of private research, stated, "I am convinced that science does not lend itself naturally to consolidation or isolation within one organization." Suggesting that a department of science might defeat the aims of those favoring it, the Secretary said that such a department "might well tend to isolate science from the daily conduct of public affairs and thus interfere with the cross-fertilization of ideas and the diffusion of scientific doctrine and method. . . ."

Wide Range of Witnesses

During the 2-day session, the subcommittee members, Hubert Humphrey (D-Minn.), Edmund Muskie (D-Me.), Homer Capehart (R-Ind.), and Ernest Gruening (D-Alaska), heard 11 witnesses from various fields. Representatives of scientific societies and commissions spoke first; they were followed by Secretary Strauss of the Commerce Department, W. O. Baker, of Bell Laboratories; Clare Boothe Luce, sponsor of the first department of science bill ever introduced in Congress; Wallace Brode, science adviser to the Secretary of State; and Dupree.

Need for Study

One suggestion that came up in the testimony of a number of witnesses concerned the need for extended study before any effective form of a department of science bill could be devised. The suggestion was made independently by Emery and by Enoch Needles, president of Engineers Joint Council, when they attempted to deal with the problem of assignment of existing agencies to a department of science. This problem of assignment or transfer of existing agencies to a new "umbrella" department was called the major hurdle before the bill by both Brode and Senator Gruening. An approach to this problem which seemed to have the approval of many witnesses and of the committee members called for the establishment of a study commission. In Brode's words: "Two major decisions are required, one as to whether a department of science should be formed and a second as to the composition of such a department. A commission of governmental and nongovernmental experts in science and nonscience areas, similar to a 'Hoover Commission' type, might consider these problems and especially consider the second phase; if a department of science is inevitable, just what activities of the government should be included?" Admiral Strauss carried this idea one step further by suggesting that the National Academy of Sciences would be the proper agency to set up such a commission.

"Technology" or "Engineering"?

The first matter that came up during the hearings was concerned with terminology. The representatives of the Engineers Joint Council suggested that the word *engineering* is both more meaningful and more appropriate than *technology* and should be used in the event a new department were established. Although Senator Gruening agreed at the time, he, with the other committee members, continued to use the noncommittal "department of science" as the hearings went on into the second day.

Another witness, Howard Meyerhoff, executive secretary of the Scientific Manpower Commission, drew expressions of concern from the subcommittee members when he said that the Office of Civil and Defense Mobilization was the only governmental body having official responsibility for over-all manpower policy. As against this situation, he recommended that "a department of science and engineering, if created, should make the manpower to implement technology the backbone of its structure." Senator Humphrey, who presided over the hearings, agreed, saying that basic problems, such as manpower, are often ignored by missile-conscious legislators.

Passage Not Imminent

Passage of a department of science bill is not imminent—a point which the

members of the subcommittee stressed during the hearings. As Senator Gruening said, "The only way we can get these opinions effectively is to have a bill. It is just like trying to get an opinion from the Supreme Court. You cannot go up and ask for it, but if you have a case in court it ultimately gets there, and then you find out what the Supreme Court thinks on the subject."

Future Hearings

At the end of the morning sessions on 17 April, Senator Gruening said that the subcommittee would reconvene that afternoon. However, other obligations of the members interfered, and the hearings were adjourned. Additional sessions are expected to take place sometime in May. Before recess, Gruening said that the committee had received letters from many persons indicating their desire to testify. Testimony from this group, which includes Lloyd V. Berkner, Leonard Carmichael, of the Smithsonian Institution, and Vannevar Bush, will probably be heard during the coming sessions.

Antarctic Mountain Range Located

A United States research team has found and measured a range of antarctic mountains whose location had been in question for 20 years. The mountains, the Executive Committee Range, were first sighted during the 1939–40 U.S. Antarctic Service Expedition in the course of a flight from Little America III. Four peaks were reported, but neither the location nor the heights could be determined. A second sighting occurred in 1947, when two Navy aircraft observers taking part in Operation Highjump reported two new peaks, one believed to be 20,000 feet high.

For a decade there was no further opportunity to investigate the range. Then a team participating in the National Science Foundation's United States Antarctic Research Program reported positive location of the mountains after a 3-week, 500-mile oversnow traverse that ended this past March. The expedition was led by John Pirrit of Glasgow, Scotland, station scientific leader at Byrd Station and glaciological project leader for the 1959 Antarctic Program.

The smallest of the ten peaks in the range is 7144 feet high—about 500 feet higher than Mount Mitchell in the Great Smokies, the highest U.S. mountain east of the Rockies. The largest peak of the antarctic range is 13,856 feet high, some 600 feet lower than Mount Rainier in Washington. The range runs north and south for about 60 miles, between 76°20′ and 77°20′S. Preliminary geological investigation shows the mountains to be volcanic and about nine-tenths covered by snow and glaciers. Alpine-type glaciers flow down from the peaks to join the vast ice sheet of Marie Byrd Land. Glaciation has modified the mountain craters. Further studies will be made next October by a seven-man party.

Peak G-3, a 10,920-foot mountain in the newly located Executive Committee Range in the Antarctic. [Courtesy U.S. Navy]

Strengthening Basic Research

Leaders in science, government, education, and industry will study ways in which basic research in the United States can be strengthened, during a Symposium on Basic Research that will take place at the Rockefeller Institute in New York, 14–16 May. The meeting is being held under the joint auspices of the National Academy of Sciences, the American Association for the Advancement of Science, and the Alfred P. Sloan Foundation. President Eisenhower will address a dinner session on 14 May. Other speakers that evening will be James R. Killian, Jr., special assistant to the President for science and technology, and Alfred P. Sloan, Jr., president of the Sloan Foundation.

Grave Concern Expressed

In announcing the program, Warren Weaver, vice president for the natural and medical sciences of the Rockefeller Foundation and chairman of the Arrangements Committee of the symposium, said:

"Our country is literally pouring money and manpower into applied research and development. Many scientists, however, are concerned because we do *not* furnish, either in amount or kind, proper support for *basic research*. It is imaginative and free basic research that is principally responsible for furnishing new knowledge. And it is new knowledge that will make our country strong and our culture rich and satisfying.

"It is the purpose of this 'Symposium on Basic Research' to set forth and examine with candor the facts concerning the support of basic research in our country, to inquire realistically what are the blocks which prevent our doing what we all say we believe is important, to make concrete suggestions as to ways in which the situation can be improved and in general to proclaim the fundamental faith which we have in the importance of free and imaginative basic research."

Participation

In order to be sure that the symposium would be geographically representative and also widely representative of the fields of science and of the institutions that support basic research, it was decided that participation would be by invitation only.

Among those who will take part will be Detlev W. Bronk, president of the National Academy of Sciences and of the Rockefeller Institute; Paul E. Klopsteg, AAAS president; and George W. Beadle of California Institute of Technology, 1958 Nobel Prize winner in medicine and physiology. Others include Alan T. Waterman, director of the National Science Foundation and a member of the

Federal Council for Science and Technology; J. Robert Oppenheimer, director of the Institute for Advanced Study, Princeton, N.J.; Allen V. Astin, director of the National Bureau of Standards; and James A. Shannon, director of the National Institutes of Health, U.S. Public Health Service.

Also, Lee A. DuBridge, president of California Institute of Technology; Robert E. Wilson, former chairman of the board, Standard Oil Co. (Ind.); James B. Fisk, president of Bell Telephone Laboratories; C. Guy Suits, vice president and director of research, General Electric Company; and M. A. Tuve, director of the department of terrestrial magnetism at the Carnegie Institution of Washington.

Program

During the first 2 days of the symposium, approximately 250 participants, in addition to session chairmen and discussion leaders, will consider material presented in 12 papers. On the final day a group of 80 to 100—panelists, chairmen, and a small number of participants—will discuss the recommendations that have been made during the preceding days and consider the policies that would best promote basic research. The results of this discussion and the 12 symposium papers will be published.

The 12 basic papers are as follows: "The Importance of New Knowledge," J. Robert Oppenheimer (director, Institute for Advanced Study); "Basic Research in the United States," Alan T. Waterman (director, National Science Foundation); "The Paradox of Choice," William O. Baker (vice president of research, Bell Telephone Laboratories); "Basic Research and the Liberal Arts College," Laurence M. Gould (president, Carlton College); "Basic Research and the State University," Conrad A. Elvehjem, (president, University of Wisconsin); "Basic Research and the Private University," Lee A. DuBridge (president, California Institute of Technology); "Basic Research in Government Laboratories," Allen V. Austin (director, National Bureau of Standards); "Basic Research in Industrial Laboratories," James B. Fisk (president, Bell Telephone Laboratories); "Basic Research in Private Research Institutes," Merle A. Tuve (Carnegie Institution of Washington); "Support of Basic Research from Government," Paul E. Klopsteg (president, American Association for the Advancement of Science); "Support of Basic Research from Industry," Robert E. Wilson [former board chairman, Standard Oil Company (Ind.)]; and "Support of Basic Research from Private Philanthropy," Robert S. Morison (director, medical and natural sciences, the Rockefeller Foundation).

Eisenhower Proposal on Nuclear Test Ban Rejected by Khrushchev

In a letter dated 13 April, the day the Geneva talks on a nuclear test ban were resumed, President Ensenhower made a personal appeal to Premier Khrushchev to work for the success of the negotiations. He stressed the need for a system of inspection and control and suggested that cessation of testing of nuclear weapons in the atmosphere up to a height of about 30 miles might be an acceptable first step toward a complete ban on tests. The Soviet delegation has objected to a step-by-step cessation.

In his reply, dated 23 April, the Soviet Premier rejected the proposal, calling it "an unfair deal." He reiterated the policy of his government, which demands a simultaneous ban on tests "in the atmosphere, underground, under water and at great altitudes."

The texts of the two notes follow.

Eisenhower's Proposal

Today the Geneva negotiations for the discontinuance of nuclear weapons tests are resuming. During the recess I have considered where we stand in these negotiations and what the prospects are for the successful conclusion which I earnestly desire. I have also talked with Prime Minister Macmillan, who reported to me his frank discussions on this matter with you.

The United States strongly seeks a lasting agreement for the discontinuance of nuclear weapons tests. We believe that this would be an important step toward reduction of international tensions and would open the way to further agreement on substantial measures of disarmament.

Such an agreement must, however, be subject to fully effective safeguards to insure the security interests of all parties, and we believe that present proposals of the Soviet Union fall short of providing assurance of the type of effective control in which all parties can have confidence: therefore, no basis for agreement is now in sight.

In my view, these negotiations must not be permitted completely to fail. If indeed the Soviet Union insists on the veto on the fact-finding activities of the control system with regard to possible underground detonations, I believe that there is a way in which we can hold fast to the progress already made in these negotiations and no longer delay in putting into effect the initial agreements which are within our grasp. Could we not, Mr. Chairman, put the agreement into effect in phases beginning with a prohibition of nuclear weapons tests in the atmosphere? A simplified control system for atmospheric tests up to fifty kilometers could be readily derived from the Geneva experts' report, and would not require the automatic on-site inspection which has created the major stumbling block in the negotiations so far.

My representative is putting forward this suggestion in Geneva today. I urge your serious consideration of this possible course of action. If you are prepared to change your present position on the veto, on procedures for on-site inspection and on early discussion of concrete measures for high-altitude detection, we can of course proceed promptly in the hope of concluding the negotiation of a comprehensive agreement for suspension of nuclear weapons tests. If you are not yet ready to go this far, then I propose that we take the first and readily attainable step of an agreed suspension of nuclear weapons tests in the atmosphere up to fifty kilometers while the political and technical problems associated with control of underground and outer space tests are being resolved. If we could agree to such initial implementation of the first—and I might add the most important—phase of a test suspension agreement, our negotiators could continue to explore with new hope the political and technical problems involved in extending the agreement as quickly as possible to cover all nuclear weapons testing. Meanwhile, fear of unrestricted resumption of nuclear weapons testing with attendant additions to levels of radioactivity would be allayed, and we would be gaining practical experience and confidence in the operation of an international control system.

I trust that one of these paths to agreement will commend itself to you and permit the resuming negotiations to make a far-reaching response to the hopes of mankind.

Khrushchev's Rejection

I have received your message of April 13 in connection with the resumption of the Geneva talks on the discontinuance of nuclear tests. I am pleased to note that you also hold the view that these talks must not be allowed to fail.

You ask whether it is not possible to begin by agreeing on a suspension of the tests of nuclear weapons only in the atmosphere at the heights of up to fifty kilometers, leaving aside, for the time being, the solution of the problem of ending the other nuclear explosions, that is, those at the heights of over fifty kilometers and underground.

The Soviet Government has given most careful and circumstantial consideration to the points made in your message, and considers that the stopping of explosions of nuclear weapons at the heights of up to fifty kilometers will not solve the problem. Suppose we sign such an agreement now. What good, one may ask, will that do the peoples who are anxious for all tests of nuclear weapons

to be banned wholly and entirely? All we would do by this would be to mislead public opinion, for the testing would, in fact, go on underground and at great altitudes.

This means that our objective of preventing the manufacture of new and more destructive types of atomic weapons will not be achieved.

On the other hand, nuclear explosions at heights of over fifty kilometers will be poisoning the air and the soil just as well, by contaminating with radioactive fall-out the vegetation which forms part of the food of animals and penetrates the human organisms, as is the case at the present time.

I think you will agree with me if I say that there is no difference, from the point of view of concern for human health, between radioactive fall-out from explosions made at a height of forty kilometers or say sixty kilometers.

Consequently, from this point of view, too, the objective we must strive to achieve will not be achieved either. Therefore, the peoples would be justified in regarding and condemning the conclusion of an agreement to stop testing only in the atmosphere at heights of up to fifty kilometers as an unfair deal.

Nor is there any need to prove that such an agreement could be concluded only figuring on the lack of knowledge on the part of public opinion.

This is out of the question, however, nowadays, as scientists would at once grasp the meaning of such an agreement and explain that it would not solve the problem, since it would leave things just as they were before the agreement was concluded.

I believe, Mr. President, that we should not flinch in the face of the difficulties, but we should muster the strength of will and show appreciation of the need to conclude an agreement providing for stopping all tests of nuclear weapons—in the atmosphere, underground, under water and at great altitudes.

I think that it is quite possible to find such a solution to the problem of ending tests, on the basis of your proposals and ours, as would meet the interests of the nuclear nations as well as those of all the other countries and to establish such a control system as would insure the strict enforcement of the agreement.

The most essential point of difference between us seems to be the question of sending inspection teams to explore the phenomena suspected to be nuclear explosions.

You know that Mr. Macmillan, Prime Minister of Great Britain, suggested during his visit to Moscow that agreement could be reached on carrying out a predetermined number of annual inspections both on the territory of the Soviet Union and on the territory of the United States and Great Britain and in their possessions, should the reports of control posts provide evidence of phenomena which may be suspected as nuclear explosions.

There would, naturally, be few such inspections. I do not think, properly speaking, that there will have to be many visits to each country.

The very fact of a possible inspection of areas, where instruments will have indicated phenomena suspected of being nuclear explosions, would check the nations and individuals who would like to stage explosions in violation of the pledges they have assumed.

This is but natural, for in that case no nation, nor any of its organizations, would avoid a true inspection of the areas where nuclear explosions are assumed to be taking place. Such suspicions, naturally, should be based not on the wishful thinking of the men in the control agency, but on the objective instrument readings.

To conclude, I should like, Mr. President, to express the hope that the Soviet Government's proposals herein stated will be appreciated by you and that we shall achieve agreement on what is one of the most important and burning issues of the day. On our part, we shall bend every effort toward achieving an agreement to end nuclear tests, and you may rest assured that if we sign a document we shall punctually abide by the pledges we shall have assumed, even if there is no control, because it is public opinion, the opinion of the peoples, that the Soviet Union values most of all.

Democrats Appoint Science Advisers

The appointment of a 17-member Advisory Committee on Science and Technology to work with the Democratic Advisory Council has been announced by Paul M. Butler, chairman of the Democratic National Committee and of the council. The chairman of the new committee is Ernest C. Pollard, chairman of the biophysics department at Yale University. The committee is composed of 17 outstanding American scientists, including two Nobel Prize winners, covering the following fields: physics, genetics, botany, anatomy, biophysics, zoology, geochemistry, engineering, and geography. The group also includes members who have special competence in the relation of science to modern warfare.

In announcing the formation of the panel, Butler said: "The Council feels that the scientific community has not been consulted sufficiently on national policies in the past six years and has been listened to even less. We want Democratic policies to be as sound as possible from the scientific and technological points of view."

Pollard pointed out that "It is not intended that the new Committee prepare or issue public statements for purely political purposes. The Democratic Advisory Council and the members of our Committee recognize that scientific and technological facts should not be the property of any political party. At the same time, we are agreed that we must do everything possible to secure the most authoritative advice in these areas to assist in sound policy formation."

Committee Agenda Outlined

Pollard said that at a small organizing meeting of the committee, held in January of this year, there was general agreement on the following tentative and partial agenda for future work of the committee: study of the relation of science to national defense policy; formulation of an adequate national science policy; formulation of legislation to promote the free exchange of nonsecret data between nations; steps to permit freer communication between U.S. and foreign scientists and engineers and to encourage the holding of international conferences in the United States; study of scientific and technical aspects of foreign development programs and foreign aid; study of the technical aspects of disarmament and the feasibility of detecting nuclear and missile tests; evaluation of local and global health hazards resulting from civilian and military uses of atomic energy; conservation of natural resources, including strategic minerals, fossil fuels, and economically useful ores; research to develop new technologies for the future; research in medical science for the welfare of upper age groups, which form an increasingly large segment of the population; analyses of deficiencies in financial or other support of research programs in the United States; projections to forecast the impact of technology upon our society and anticipate problems before present trends make solutions impossible; appraisal of the adequacy of the U.S. national effort in space research; projection of the impact of automation techniques upon society; and recommendations concerning science in relation to education.

Members

The first meeting of the Science and Technology Committee was held in the Washington offices of the council on 26 April. In addition to Pollard, committee members include Samual K. Allison of the University of Chicago, Harrison S. Brown of California Institute of Technology, Leslie C. Dunn of Columbia University, Louis B. Flexner of the University of Pennsylvania, Trevor

Gardner of the Hycon Manufacturing Company (Washington, D.C.), H. Bentley Glass of Johns Hopkins University, David R. Goddard of the University of Pennsylvania, Frank Goddard of the California Institute of Technology, David L. Hill of New York City, Polykarp Kusch of Columbia University, Charles C. Lauritsen of California Institute of Technology, F. T. McClure of Johns Hopkins University, Richard B. Roberts of the Carnegie Institution (Washington, D.C.), John S. Toll of the University of Maryland, Harold C. Urey of the University of California (La Jolla), and Gilbert F. White of the University of Chicago.

National Space Council

At a hearing of the aeronautical and space sciences committee of the Senate, T. Keith Glennan, head of the National Aeronautics and Space Administration, refused last month to discuss the policy-making procedures of the National Space Council because of its "confidential" relationship to President Eisenhower. The council, established at the same time as NASA, has as members the President, the secretaries of State and Defense, the administrator of NASA, the chairman of the Atomic Energy Commission, and four other presidentially appointed persons. It has the role of advising the President on the broad outlines of aeronautical and space activities in the country.

After complaints had been made by various committee members, Glennan said that he would be glad to ask the President to reconsider the executive decision that makes the council meetings "privileged" with respect to Congressional inquiry. Since its formation about 5 months ago the council has had four formal meetings and one informal session, according to Glennan.

News Briefs

The United States and Canada have announced a nonmilitary cooperative research program for exploring the ionosphere over the Arctic. Under the program, the National Aeronautics and Space Administration will furnish several research rockets to the Canadian Defense Research Telecommunications Establishment. Later, probably toward the end of 1960, the United States will launch a satellite containing instruments designed and built in Canada.

* * *

The U.S. Atomic Energy Commission has a nuclear energy exhibit in the Tokyo International Trade Fair, being held in Tokyo, Japan, 5–22 May. Some of the U.S. displays shown at the Second International Conference on the Peaceful Uses of Atomic Energy at Geneva, Switzerland, last September and new exhibits by U.S. individuals, colleges and universities, industrial firms, and government agencies comprise the commission's presentation. Highlight of the exhibit is the cutaway model of the Shippingport reactor pressure vessel and core that was on display at Geneva.

* * *

A total of 255 reports on radiation sources, effects, measurements, and related problems have been submitted to the United Nations Scientific Committee on Effects of Atomic Radiation since it first began work 3 years ago. The reports have come from 30 governments on all continents, from four specialized agencies of the U.N., and from two nongovernmental scientific bodies. When the 15-member Scientific Committee held its sixth session at U.N. Headquarters 23 March to 1 April, it expressed hope that it would continue to receive relevant information on radiation levels and their effects from members of the U.N., the specialized agencies, or the International Atomic Energy Agency.

* * *

Graduate Study in France, a publication designed for students planning a period of study at French institutions, has been issued by the French Cultural Services, 972 Fifth Ave., New York. It contains information on degrees, specialized institutes, fellowships, and teaching assistantships and gives details on application procedures, living accommodations, and visa requirements.

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The first internationally organized training course on radioisotope techniques designed specifically for the needs of the research worker in agriculture, forestry, fisheries, and nutrition is being arranged jointly by the Food and Agricultural Organization of the United Nations and the International Atomic Energy Agency, in cooperation with the United States Government and Cornell University. The 8-week course, to be held at Cornell beginning 20 July, will be open to nominees officially sponsored by member governments.

Grants, Fellowships, and Awards

Atherosclerosis. The Biochemistry Research Division, Sinai Hospital of Baltimore, Inc., has established a postdoctoral training program in lipid chemistry related to atherosclerosis and aging. The new program, which is supported by the National Heart Institute, will emphasize training in the newer techniques of gas chromatography and silicic acid column chromatography. Trainees with a Ph.D. in chemistry or biochemistry, or M.D.'s will be accepted for periods of from 2 months to 2 years; stipends will be provided from the program. Applications are now being received by the program director, Dr. David A. Turner, Biochemistry Research Division, Sinai Medical Center, Baltimore 15, Md.

Botany. The Committee on the Darbaker Prize of the Botanical Society of America is accepting nominations. Nonmembers of the society are eligible for the award, which is given for meritorious work in the study of the algae. The committee will base its judgment primarily on the papers published by the nominee during the last two full calendar years prior to the closing date for nominations. At present, the award will be limited to residents of North America, and only papers published in English will be considered. Nominations for the 1959 award, accompanied by a statement of the merits of the case and by reprints of the publications supporting the candidacy, should reach the chairman of the committee *before 1 June*. The chairman is Ruth Patrick, Academy of Natural Sciences of Philadelphia, Philadelphia, Pa.

Marine biology. The U.S. Atomic Energy Commission's Division of Biology and Medicine has announced that the Eniwetok Marine Biological Laboratory is again available for use by scientists for research that can be carried on advantageously on a central Pacific atoll. The laboratory is equipped for all types of biological collecting and for ecological, physiological, and radiobiological studies. Should investigators submit projects which fall within the interests of the Division of Biology and Medicine, funds may be made available for travel, per diem, and other expenses incurred in the course of the project.

Scientists should submit proposals for research at Eniwetok to the Chief, Environmental Sciences Branch, Division of Biology and Medicine, U.S. Atomic Energy Commission, Washington 25, D.C. Only men may go to Eniwetok, and a security clearance is mandatory. Because processing procedures require considerable time, proposals for conducting research at Eniwetok must be submitted at least 3 months before the expected date of departure.

Mycology. The New York Botanical Garden has announced the Gertrude S. Burlingham scholarship in mycology for advanced predoctoral summer study at the Garden. The scholarship will be granted annually. For the summer of 1959 the stipend will be $700; work under this appointment may begin any time after 1 July and should continue for approximately 3 months. Nominations or applications should reach the director *by 15 May*. Further information may be obtained from William C. Steere, New

York Botanical Garden, New York 58, N.Y.

Public health. Nominations for the sixth Kimble Methodology Research Award are being accepted *until 1 June.* This award, made in recognition of the application of scientific knowledge in the public health laboratory, was established by the Kimble Glass Company of Toledo, Ohio (subsidiary of the Owens-Illinois Glass Company) and is sponsored by the Conference of State and Provincial Public Health Laboratory Directors. The cash award of $1000 and silver plaque will be presented at the annual meeting of the Conference, to be held in Atlantic City, N.J., in October 1959.

To be considered for nomination, a candidate should have done work which is either (i) a fundamental contribution that serves as a base line for development of diagnostic methods which fall within the province of the public health laboratory, or (ii) the adaptation of a fundamental contribution to make it of use in a diagnostic laboratory. For information, write to E. T. Bynoe, Chairman Nominating Committee, Kimble Award, Laboratory of Hygiene, Department of National Health and Welfare, Ottawa, Ontario, Canada.

Steroid biochemistry. The fourth session of the Training Program for Steroid Biochemistry, sponsored by the U.S. Public Health Service, will begin on *1 October.* Applications are invited at the postdoctoral level for a 1-year tenure with a stipend of $5500. The program consists of lectures, planned laboratory, and 8 months of research at the Worcester Foundation for Experimental Biology and Clark University or the University of Utah. Inquiries should be addressed to William R. Ness, Department of Chemistry, Worcester, Mass., or to Kristen Eik-Nes, College of Medicine, University of Utah, Salt Lake City. A predoctoral program also will be carried out in Worcester, with stipends of $1800 for 6 months. All applications must be received *before 1 June.*

Scientists in the News

CHARLES L. WISSEMAN, JR., professor of microbiology and head of the department at the University of Maryland School of Medicine, left on 19 April for a month in Tokyo, where he will work with Japanese investigators at the Japanese National Institute of Health on immunization problems involving dengue fever and related viruses.

LAURENCE PICKEN, assistant director of research in zoology at the University of Cambridge, England, and a fellow of Jesus College, has been appointed Walker Ames professor of zoology at the University of Washington for the spring semester. He will present a series of graduate seminars entitled "Topics in Biological Organization."

Seventeen awards for outstanding contributions to chemistry and chemical engineering, most of them for $1000, were presented at the American Chemical Society's 135th national meeting.

HERMANN I. SCHLESINGER of the University of Chicago has received the Priestley Medal, highest honor in chemistry in the United States.

DOROTHY V. NIGHTINGALE of the University of Missouri department of chemistry has received the Garvan Medal for outstanding service to chemistry by a woman chemist.

ALTON L. BLAKESLEE, science writer for the Associated Press, New York, has received the James T. Grady Award for distinguished reporting of chemical progress.

JOHN P. MIXNER, professor of dairy husbandry at Rutgers State University, has received the 1959 New York Farmers Award. The $500 prize is awarded to a resident of Connecticut, Massachusetts, New Jersey, or New York, for outstanding achievement in the field of agriculture.

B. J. MASON, professor at the Imperial College of London and research fellow of the Royal Society, will spend this summer and fall in the department of meteorology at the University of California, Los Angeles, as visiting professor and research meteorologist.

Five American scientists, members of a biochemistry delegation, left this country on 25 April for a 4-week visit to the U.S.S.R. The trip was arranged by the Public Health Service under the U.S.-U.S.S.R. Exchange Program. Members of the delegation are HERBERT CARTER, head, department of chemistry, University of Illinois, Urbana; KONRAD E. BLOCH, professor of biochemistry, Harvard University; ARTHUR KORNBERG, professor of microbiology, Washington University School of Medicine, St. Louis; ALBERT L. LEHNINGER, chairman, department of physiological chemistry, Johns Hopkins University; and BERNARD D. DAVIS, professor of bacteriology, Harvard Medical School.

RALPH A. SAWYER, professor of physics and dean of the Horace H. Rackham School of Graduate Studies at the University of Michigan, has been named chairman of the governing board of the American Institute of Physics. He succeeds FREDERICK SEITZ, professor of physics at the University of Illinois.

SHINYA INOUE, associate professor of biology at the University of Rochester, has been appointed professor of cytology and chairman of the department at Dartmouth Medical School. WAYNE THORNBURG of the department of anatomy at the University of Washington School of Medicine will join Dartmouth Medical School as associate professor of cytology.

DONALD H. FLEMING, formerly professor of history at Brown University and a specialist on the impact of science on American thought, will become professor of history at Harvard University, effective 1 July.

WILBUR A. THOMAS, associate professor of pathology at Washington University School of Medicine, has been named chairman of the department of pathology at Albany Medical College and pathologist in chief at Albany Hospital, effective 1 July. He will succeed ARTHUR W. WRIGHT, who has been department chairman for 25 years. Wright will continue as professor of pathology and as an active member of the department.

ROBERT E. ZINN, senior chemical engineer with Vern E. Alden Company, Chicago, and professor of chemical engineering on leave of absence at Northwestern University, has joined the senior staff of Arthur D. Little, Inc., Cambridge, Mass.

LOUIS L. RUSOFF, dairy nutritionist at Louisiana State University, has been awarded the Coates Memorial Award of the American Chemical Society and American Institute of Chemical Engineers. The prize is awarded to the outstanding chemist or chemical engineer in the Baton Rouge area.

STANFIELD ROGERS, director of the Memorial Research Center at the University of Tennessee, has received the third annual $1000 award of the American Society for Experimental Pathology.

PARKHURST A. SHORE, head of the section on biochemistry of drug action, Laboratory of Pharmacology, National Heart Institute, Bethesda, Md., recently received the John Jacob Abel Prize for the American Society for Pharmacology and Experimental Therapeutics. The $1000 award is sponsored by Eli Lilly and Company.

I. E. WALLEN, foreign training officer in the Atomic Energy Commission's Division of International Affairs, has joined the commission's Division of Biology and Medicine as aquatic biologist in the environmental sciences branch.

Book Reviews

The Ancient Mariners. Seafarers and sea fighters of the Mediterranean in ancient times. Lionel Casson. Macmillan, New York, 1959. xx + 286 pp. Illus. $5.95.

Modern historical scholarship is producing increasingly precise studies of the maritime activities of the ancient nations, particularly of the classical period. The latest contribution in this field is Lionel Casson's book. This is a concise description of the development of sea trade, of exploration, and of formal naval warfare through national migration, piracy, and expansion of empire from the dawn of recorded history to the collapse of the Roman Empire. Though intended for the general reader, the book is based upon very extensive research and is written with great precision.

Casson has reproduced in modern language some of the trade correspondence and legal briefs of the ancients; these, together with a running account of historical events, give an excellent picture of sea trade in Egyptian, Athenian, and Roman times. In addition, there are very useful appendices: a table of dates, which, though often approximate, give a sense of the chronological order of events; a well-selected bibliography with references to chapter and page; and, finally, an important addition, a "Glossary of Greek and Latin nautical terms." The illustrations of ancient ships are adequate.

It is almost impossible to discuss ancient maritime history without describing the ships employed. This leads to the problems of hull design, construction, and propulsion. There is a mass of literary and artistic evidence available that requires interpretation; such interpretation is made difficult by an almost total lack of technical information on the subject. Casson has dealt with this troublesome matter in a common-sense manner.

The method of rowing and the arrangement of the rowers in ancient galleys has long been a matter of controversy among scholars and also among technical experts. The three-banked triremes of the 5th century B.C., of which the fleet of Athens was made up in her days of naval power, are the basic source of controversy.

There is a school of thought that interprets the evidence, literary and artistic, as indicating that the rowers of a trireme sat in three superimposed banks (in echelon, when the ship was viewed broadside on), each rower having an oar. This may be said to be the natural assumption, after inspection of contemporary vase paintings and relief carvings. There are differences of opinion within this school about the positions of the banks of rowers, particularly of the upper two, viewed transversely. For many years it was assumed that the lowest bank of rowers sat nearest the side of the hull, the uppermost bank being inboard of the second, and that the hull was either vertical or flared in the rowing chamber. The modern opinion is that the uppermost bank, at least, was "outrigged," on a projecting frame along the rowing chamber, the rowers in this bank being seated a little above and outboard of the second bank and nearly over the lowest bank. By this arrangement it would also be possible to place the upper two banks on the same level, with but slight modifications in seating arrangement.

In all of these attempts at reconstruction it is assumed that each rower had his individual oar, and that the oars were in three lengths. The shortest oar was used by the lowest bank. The upper two banks are believed by some to have used oars of the same length when the rowers in the two banks were seated at the same level. Most recently the English authority J. S. Morrison, writing in the *Mariners' Mirror,* the journal of the Nautical Research Society [**27**, No. 1 (1941)], suggested that all three banks used oars of the same length, and he modified the modern concept of the seating arrangement in accordance with this belief. Morrison suggested, as one of two possibilities, that the blades of the oars struck only a very narrow band of water, parallel to the rowers.

The second school of thought dismisses all of the foregoing as impractical and assumes that the rowers were all on one level, sitting on staggered or raking thwarts, each with his individual oar. The oarlocks or pins of the oars were thus in closely spaced groups of three on the "outrigger frame" or *apostis.* This was the grouping, called *a zenzile,* once used in Venice. Thus, the method is shown to be practical, though there appear to be some very obvious difficulties involved in trying to interpret the contemporary pictorial evidence in line with this concept.

None of these reconstructions seem to fit when we consider the various galleys of later date than the trireme—galleys in which four, five, and up to 30 banks are mentioned by ancient writers. It seems probable that the arrangement of the banks of rowers must have changed during the existence of the trireme, and it is possible that more than one system was used; the most probable arrangement is one of three or possibly four banks, with more than one man to an oar. Four banks would appear to be the limit to which arrangements involving superimposed banks could be carried.

It may be observed that superimposed banks of rowers in two levels, one on each deck, were employed in some of the 24-gun ships of the British navy about 1745; *Centaur,* a ship of this class, was so fitted out, as is shown in her building plan. In her case it seems probable that oars in two lengths must have been employed, and it is doubtful whether the insistence that the oars of a trireme must necessarily have been all of one length is warranted.

Casson has accepted Morrison's reconstruction, which is workable in a full-size vessel, at least. He has taken too seriously, perhaps, some of the estimates of size given in ancient literature. However, there is at least some justification for this, for peoples like the ancient Egyptians, Greeks, and Romans, who were capable of building large and well-designed engineering structures, might well have been capable of building large wooden ships on occasion. Casson has avoided the too common error of underestimating the capabilities of the ancient shipwrights and mariners.

The Ancient Mariners is an excellent addition to any marine library, for it is a book to which both the general reader and the specialist will refer when interested in maritime matters of the classical period.

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Phosphorus and its Compounds. vol. 1, *Chemistry.* John R. Van Wazer. Interscience, New York, 1958. xiii + 954 pp. Illus. $27.50.

In volume 1, Van Wazer presents an intelligent account of the chemistry of phosphorus and its compounds. He is to be commended for this effort to bring order out of such a complex mass of material and to make available data and information in a form which will be useful to workers in the various fields of phosphorus chemistry.

The author states that he has not ex-

haustively reviewed the literature but has covered it sufficiently to enable the reader to locate the entire literature on any particular subject of interest.

The scope of the book may be seen from the division of the subject matter into the following chapters: "The phosphorus atom, its nucleus and electronic structure"; "Interaction between atoms, with especial reference to phosphorus chemistry"; "Systematic chemistry of phosphorus and its compounds"; "Elemental phosphorus and the metal phosphides"; "Hydrides, halides, and pseudohalides of phosphorus and their organic derivatives"; "Oxides, sulfides, nitrides, and related compounds of phosphorus"; "Lower oxyacids of phosphorus, their salts and esters"; "Structure and properties of the condensed phosphates"; "Orthophosphoric acid, its salts and esters"; "Individual chain phosphates (pyro-, tripoly-, tetrapoly-, and pentapolyphosphates as well as Kurrol's salt and Maddrell's salt)"; "Ring and branched phosphates"; "Amorphous phosphates, including phosphate glasses, condensed phosphoric acids, and phosphate esters"; and "Halo-, peroxy-, thio-, and amidoacids of phosphorus, their salts, esters, and related compounds."

In addition, the book contains three appendices. Appendix A lists 187 accepted mineral names for phosphates, together with the chemical formulas, crystallographic data, and associated minerals. Appendix B contains a collection of single-bond energies and distances, with electronegativity differences for use in calculations concerning phosphorus compounds. Appendix C contains available thermodynamic data on the compounds of phosphorus.

Volume 2, still in preparation, will be devoted to the technology, functions, and applications of phosphorus and its compounds.

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The Atomic Age and Our Biological Future. H. V. Brøndsted. Translated by E. M. Huggard. Philosophical Library, New York, 1957. xiv + 80 pp. $2.75.

This little book is an attempt to supply the physical and biological background needed for an assessment of present and future radiation hazards. The author is professor of zoology at the University of Copenhagen, and the book is based on a series of his public lectures.

The first chapter is an elementary, simplified account of the structure of matter and the nature of radiation. Then follow sections on heredity, mutation, and embryogenesis and on the effects of radiation in these areas. The style is simple, and full use is made of analogies.

The over-all effect of the book is to create a correct impression—that is, that radiation can produce both genetic and somatic damage, and that suitable precautions are necessary. Yet there are so many factual errors, inconsistencies, oversimplifications, and vague statements that the book is of limited use for the serious reader. Perhaps it has suffered in translation, for some words are used in an unusual way, or even incorrectly. For example, *fallout* is given a meaning that is different from the customary one. On page 52, background radiation is given as one five-thousandth of a roentgen per week, whereas one five-hundredth would be more nearly correct.

So much has been written on this subject that this book does not fill a great need. There are much better sources of information—for example, the United Nations report; and there are other publications on the subject, as easy to read as this book, that are not marred by so many errors.

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Manuale di Micologia Medica. Raffaele Ciferri. Renzo Cortina, Pavia, Italy, 1958. 370 pp. L. 4000.

As a reflection of the growing interest in medical mycology throughout the world, manuals dealing with the fungus diseases of man have been published in many countries. Notable books have been written by mycologists in Argentina, Belgium, Brazil, Czechoslovakia, England, France, India, the Netherlands, and the United States. The latest addition to this growing family of publications is the present book, the first of two volumes, written by Raffaele Ciferri, director of the Botanical Institute and Cryptogamic Laboratory of the University of Pavia (Italy). This first volume is intended to provide basic information for the physician who is embarking upon the study of human pathogenic fungi with little or no training in mycology.

The author has fulfilled his objective admirably, for in the ten chapters of this volume a wealth of information, both theoretical and practical, is presented. This material, if assimilated, should enable the invesigator to detect, isolate, and identify fungi in clinical materials of all types.

In chapter 1, a concise history of the science of medical mycology is presented, along with a discussion of the nomenclature and classification of the mycoses. The biological affinities of fungi to other living organisms are discussed, and this is followed by a review of the taxonomy and nomenclature of the fungi. The chapter closes with a brief summary of the histological differences between deep mycotic infections and the superficial mycoses.

The activities of fungi as allergens, symbionts, and parasites and their industrial and pharmacological value are covered in the second chapter.

The next two sections are devoted to a thorough discussion of the morphology, physiology, ecology, and classification of the fungi.

Chapters 5 and 6 deal with specific techniques for the microscopic examination and culture of fungi. These are followed by a chapter on the preparation of antigens and their utilization in serological and skin tests.

Chapter 8 describes pathogenicity tests and their value in the identification of fungi.

A dichotomous key designed to aid in the diagnosis of all the mycoses constitutes chapter 9.

The book concludes with a brief discussion of the therapy of fungus diseases, some remarks on the publication of research findings, and an extensive bibliography. The bibliography cites general mycologic texts and books that deal specifically with medical mycology and includes a selected list of current papers on pathogenic fungi and the diseases that they cause.

The book is of a convenient size and is printed on glossy paper of a good quality. Simple line drawings and several photomicrographs are used to illustrate the text.

On the whole, the author has more than adequately fulfilled his objective of providing useful background information for the study of human pathogenic fungi. Objection can be taken to the classification schemes and nomenclature employed. For example, no valid evidence exists for considering *Coccidioides immitis* to be a phycomycete and for placing it in a special order, the "Coccidiales." Few mycologists will agree that sexual reproduction has been verified in the life cycle of *Cryptococcus neoformans*. Thus, the placement of this anascosporogenous yeast in the genus *Debaryomyces* is of questionable validity. The use of the generic names *Gilchristia* and *Scedosporium* for *Blastomyces dermatitidis* and *Monosporium apiospermum*, respectively, is also contrary to current usage. I also object to the use of *Rhinocladium beurmani* as the preferred name for *Sporotrichum schenckii*.

The most serious limitation in the value of this volume is the absence of an index. While an index for both volumes undoubtedly will be included in the second volume, it would be more convenient for the reader if the contents of each volume had been indexed separately.

The points of criticism raised are relatively minor, and such shortcomings will not detract seriously from the value of this comprehensive work on the basic aspects of medical mycology. This manual is recommended to the serious student. It is regrettable that its usefulness will be limited only to those with a good reading knowledge of Italian.

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Low Temperature Physics and Chemistry. Proceedings of the Fifth International Conference on Low Temperature Physics and Chemistry. Joseph R. Dillinger, Ed. University of Wisconsin Press, Madison, 1958. xxv + 676 pp. $6.

In late August 1957 the University of Wisconsin was host to 440 scientists at the Fifth International Conference on Low Temperature Physics and Chemistry. With the exception of those in Soviet Russia, most of the active cryogenic laboratories in this country and abroad were represented, and the lively sessions covered a sizable fraction of the problems of current interest in this field. This volume, which includes a three- to four-page version of each of the 198 contributed papers and slightly longer reports of the 27 invited papers, provides not only an unusually complete summary of the conference proceedings but a highly valuable progress report on a popular field of research.

About a third of this book is devoted to the behavior of liquid He^4, liquid He^3, and liquid He^3-He^4 mixtures, sometimes called quantum liquids. Superconductivity, including applications of superconducting switches and persistent currents to computing machines, is thoroughly discussed. The following topics are also covered: temperature scale and temperature measurement, transport properties in solids at low temperatures, specific heats, mechanical properties of solids and solidified gases at low temperatures, magnetic properties, nuclear and paramagnetic resonance, and nuclear orientation experiments. The broad range of topics reflects the growing interest in the behavior of matter near the absolute zero of temperature.

Since much of the material in this book is not yet available elsewhere, this is an essential reference volume for active research workers in the field and should be of interest to a somewhat wider audience.

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Cerenkov Radiation and its Applications. J. V. Jelley, Pergamon, New York, 1958. x + 304 pp. Illus. $10.

By a happy coincidence Jelley's monograph became available almost simultaneously with the announcement of the award of the 1958 Nobel Prize for physics to P. A. Cerenkov, I. M. Frank, and I. E. Tamm for their pioneering work on the "Cerenkov effect." Jelley has written a timely, authoritative, and very complete account of the discovery, properties, and applications of this interesting phenomenon.

In the introduction the work of these three Russian physicists is given perspective within the framework of earlier experiments (the observation of Cerenkov radiation dates back almost to the discovery of radioactivity), and the credit reflected by the Nobel award is undisputed. It is interesting to note, however, that the contribution made by S. I. Vavilov, Cerenkov's professor at the Lebedev Institute, which is inconspicuous both in Jelley's review and in the literature, has been emphasized lately by the adoption in the U.S.S.R. of the more inclusive name "Vavilov-Cerenkov effect."

After a summary of the theory of "ordinary" Cerenkov radiation, a long and fascinating chapter describes many of the more exotic circumstances in which the radiation may be emitted. In some of these cases the phenomenon is potentially useful; in others it is quite unobservable. A large part of the volume is of course concerned with the practical detection of charged particles and the determination of their velocities. There is a comprehensive review of the types of counter that have already been used and of their advantages, and some hints are given of future possibilities.

One property of the Cerenkov counter that is surely destined to be exploited further is its inherent speed, and one would perhaps like to have seen more discussion of the speed of the photomultiplier which sets the practical limit in this direction. A more trivial omission is a sketch of the DuMont box dynode structure, which would have completed the set of illustrations of various basic designs. Again, one might quarrel with the statement that only the measurement of Cerenkov angle with the focusing type counter is useful for the direct determination of velocity. If the angular divergence of the particle beam becomes sufficiently large, there comes a point where better velocity resolution is achieved by measuring intensity, and to this end I have used nonfocusing counters successfully in cosmic-ray experiments.

Such shortcomings detract little, however, from the value of this book, which manages to combine very satisfactorily an introduction to the subject for the uninitiated with reference material for the expert. Included are many useful tables and graphs and a comprehensive list of references that is especially to be praised for its coverage of the extensive Russian literature. The care with which the volume has been edited is shown by the fact that I found only one typographical error. It occurs on page 157 and is sufficiently obvious to be harmless.

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International Bibliography of Social and Cultural Anthropology. vol. 1. Prepared by the International Committee for Social Sciences Documentation. Georges Balandier and J. F. M. Middleton, Eds. United Nations Educational, Scientific, and Cultural Organization, Paris, 1958 (order from UNESCO Publications, 801 Third Ave., New York 22). 259 pp. $5.50.

Publication of the *International Bibliography of Social and Cultural Anthropology* is a part of the general program of the International Committee for Social Sciences Documentation—a committee formed in 1950 with UNESCO support. The purpose of the committee is to promote the development of all bibliographical and documentary work of interest to the social sciences. The committee is made up of representatives of the various disciplines, nominated by the international scientific associations—the International Social Science Council, the International Sociological Association, the International Economic Association, the International Political Science Association, the International Association of Legal Science, the International Union of Scientific Psychology, the International Federation for Documentation, and the International Federation of Library Associations.

The committee considers that its main task is to supply each social science discipline with the basic bibliographical work essential to it. In certain fields it seemed essential to create annual international bibliographies; the *International Bibliography of Social and Cultural Anthropology* is one such bibliography.

It is the aim of the committee to record all publications concerned with the discipline, whatever the country of origin of the publication or the language in which it is written. They seek to list all scientific publications—books, articles in periodicals, reports distributed in duplicated form—but they exclude unpublished works (for instance, theses which have been merely typed), articles appearing in the daily press, and so forth. Special attention is paid to official publications of governments.

The classification scheme of the bibliography is as follows: "Anthropology: general studies"; "Material and methods of anthropology"; "Morphological foundations"; "Monographs"; "Social organization and social structure"; "Religion, magic and witchcraft"; "Problems of knowledge, arts and science"; "Statics and dynamics of social and cultural systems"; and "Applied anthropology."

An author index and two subject indexes (English and French) are included.

Environmental Conservation. Raymond F. Dasmann. Wiley, New York, 1959. x + 307 pp. Illus. $6.50.

Recent books on conservation have fallen into two types: those of the "plundered planet" school, which view our future with alarm (as well they should), and the bulky textbooks loaded with tables, graphs, and other paraphernalia that encourage only the fragmentary reading of assigned pages by students in a course.

This book—a vigorous hybrid—is a concisely stated, well-written textbook for college courses in conservation that should at the same time appeal to nonprofessional readers. The text is so clear that the book could also be read by high-school students and by small-town, conservative newspaper editors. The basic theme, as indicated by the title, is that conservation is not a matter of water, trees, or petroleum but of entire environments—of ecosystems. The traditional separation into the various aspects or resources is followed in chapter arrangements as a matter of convention, but the integrating role that conservation practice should play in our modern culture is never lost sight of.

It is all too easy for conservationists to become strident—remembering the land in the kindness of its youth, in the wilderness before it was yet sown—for like Jeremiah they have the true vision of our doom. Dasmann is to be congratulated for the restraint with which he has handled these matters. He writes soberly of the problem of Los Angeles but leaves the reader to conclude for himself how badly out of balance this city is in an ecological sense (some of us would be tempted to call it an ecological cancer), and he poses the problem of population increase in his concluding chapters in such a way that the student will realize that what is really needed is hard, sober thought. We have still a distance to travel before a thoughtful person who takes the position that economic and population growth are not necessarily good things in themselves is not regarded in many communities as an opponent of "progress," if not a nature-loving crackpot, but books like this should, if time is still with us, help to create a more thoughtful climate for the conservation of our environment. Students are as allergic to sermons as are chambers of commerce, and the author has obviously been aware of this in writing his book. The result is a text that deserves wide usage, and one that will serve almost equally well as an introduction to ecology or to conservation.

The book is well illustrated, with many fine photographs (although a few have inevitably lost contrast in reproduction); there are excellent lists of chapter references and an 11-page index. It is also compact and has an attractive cover—features which should encourage its possessors to carry it about in preference to their bulkier textbooks for less essential courses.

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Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

An Analysis of Mixtures of Volatile Substances. Annals, vol. 72, art. 13, Emil F. Williams, Ed. 215 pp. $4. *Quantum Aspects of Catalysis: the Drying of Linseed Oil.* Annals, vol. 79, art. 1. Raymond R. Myers. 8 pp. $0.50. New York Acad. of Sciences, New York, 1959.

Ataractic and Hallucinogenic Drugs in Psychiatry. WHO Tech. Rept. Ser. No. 152. 72 pp. $0.60. *Introduction of Radiation Medicine into the Undergraduate Medical Curriculum.* WHO Tech. Rept. Ser. No. 155. 24 pp. $0.30. *Expert Committee on Training of Health Personnel in Health Education of the Public.* WHO Tech. Rept. No. 156. 40 pp. $0.30. World Health Organization, Geneva, 1958 (order from Columbia Univ. Press, New York.)

Blue-Green Algae from the Middle Devonian of Rhynie, Aberdeenshire. Bulletin, Geology, vol. 3, No. 10. William N. Croft and Eric Alan George. 14 pp. 8s. *A Study of the New Zealand Chironomidae (Diptera, Nematocera).* Bulletin, Entomology, vol. 7, No. 9. Paul Freeman. 44 pp. 12s. 6d. British Museum (Natural History), London, 1959.

Development and Structure of the Frog. A photographic study. Addison E. Lee, Earl R. Savage, W. L. Evans. Rinehart, New York, 1959. 44 pp. $1.

Diseases of the Colon and Rectum. vol. 2, No. 1. Louis A. Buie, Ed. Lippincott, Philadelphia, Pa., 1959. 158 pp.

Federal Grants and Contracts for Unclassified Research in the Life Sciences. Fiscal year 1957. National Science Foundation, Washington 25, 1958. 321 pp.

First Annual Texas Conference on the Utilization of Atomic Energy. Proceedings. A&M College of Texas, College Station, 1958. 60 pp.

Free-Living Nematodes and Other Small Invertebrates of Puget Sound Beaches. Wolfgang Wieser. Univ. of Washington Press, Seattle, 1959. 189 pp. $4.

Furbearers in Kansas: a Guide to Trapping. Howard J. Stains and Rollin H. Baker. State Biological Survey and Museum of Natural History, Univ. of Kansas, Lawrence, 1958. 100 pp. $0.50.

A Further Study of Micronesian Polyclad Flatworms. No. 3410. Proceedings of the U.S. National Museum, vol. 108. Libbie H. Hyman. Smithsonian Institution, Washington, D.C., 1959. 54 pp.

Genetics Laboratory Guide. David J. Merrell. Burgess, Minneapolis 15, 1959. 32 pp. $1.50.

The Geology and Mineral Resources of Athens County, Ohio. Bulletin 57. Myron T. Sturgeon. Div. of Geological Survey, State of Ohio, Columbus, 1958. 600 pp. $3.

Librarian of Congress, Annual Report of. For the fiscal year ending 30 June 1958. Library of Congress, Washington, D.C., 1959 (order from Supt. of Documents, GPO, Washington 25). 179 pp.

Nourishing Brain Cells. C. E. Lumsden. Leeds Univ. Press, Leeds, England, 1959. 23 pp. 2s. 6d.

Preparing Climatic Data for the User. Tech. Note. No. 22. H. E. Landsberg. 19 pp. F. 4. *Meteorology as Applied to the Navigation of Ships.* Tech. Note No. 23. 26 pp. F. 4. *Turbulent Diffusion in the Atmosphere.* Report of a working group of the Commission for Aerology. Tech. Note No. 24. C. H. B. Priestley, R. A. McCormick, F. Pasquill. 68 pp. F. 7. World Meteorological Organization, Geneva, Switzerland, 1958.

Promising Practices in Nutrition Education, in the Elementary School. Willard J. Jacobson, Fannie Lee Boyd, Mary M. Hill. Bureau of Publications, Teachers College, Columbia Univ., New York, 1959. 54 pp. $1.

Research in Space Science. Special Rept. No. 19, 20 pp.; Special Rept. No. 20, 46 pp.; Special Rept. No. 21, 37 pp. Smithsonian Institution, Astrophysical Observatory, Cambridge, Mass., 1959.

Safflower Trials in Australia. Division of Plant Industry Tech. Paper No. 11. B. Horowitz and C. R. Kleinig. Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia, 1958. 19 pp.

Social Science Research Council, Annual Report 1957–1958. The Council, New York, 1959. 100 pp.

Studies on Fishes of the Family Characidae. No. 16. A new Hyphessobrycon from Costa Rica. Bulletin of the Florida State Museum, Biological Sciences, vol. 3, No. 4. James E. Bohlke. Univ. of Florida, Gainesville, 1958. 8 pp. $0.14.

The Supervisor of Mathematics, His Role in the Improvement of Mathematics Instruction. Natl. Council of Teachers of Mathematics, Washington 6, 1959. 10 pp. $0.15.

Three New Skinks Related to Sphenomorphus variegatus (Peters). Fieldiana: Zoology, vol. 39, No. 24. Robert F. Inger. Chicago Natural History Museum, Chicago, Ill., 1958. 11 pp. $0.30.

Reports

Visuo-Motor Integration in Split-Brain Cats

Abstract. Chiasm- and callosum-sectioned (split-brain) cats and controls were trained to displace the correct one of two different objects, using each forelimb half the time. During this discrimination training, vision was restricted to one eye, thus confining visual input and learning to a single hemisphere in the split-brain animals. It was found that either forelimb could be used about equally well by all the animals.

It has recently been shown that interocular transfer of visual discrimination learning is abolished in both cat and monkey by section of the optic chiasm and corpus callosum (*1*). Apparently, information essential to the learning and recall of visual discriminations fails to reach the contralateral hemisphere when the split-brain cat or monkey is obliged to use one eye.

The experiment described in this report was designed to determine whether there is any impairment in the ability of split-brain cats to respond discriminatively to visual stimuli with the forelimb homolateral to the hemisphere receiving the essential visual information. The major cortical motor centers for this limb lie in the hemisphere contralateral to and surgically separated from that of the visual input. Previous experiments on callosum-sectioned animals and human beings (*2*) have not revealed any deficits in bilateral motor coordination or in bilateral transfer of motor learning. However, systematic study of the motor performance of callosum-sectioned animals in which critical sensory information is restricted to one hemisphere is lacking.

Twelve cats served as the subjects (*3*). In seven of the animals, the chiasm and the callosum were sectioned in the midline, and in two, the chiasm alone was sectioned. The remaining three were normal controls. Beginning at least 4 weeks after the operation, the animals were trained to displace a wood block with a forelimb in order to obtain a piece of food covered by the block. During this preliminary training, the animals were adapted to a rubber mask, which restricted vision to one eye, and then to a forelimb restrainer, which consisted of a leather wristband and chain. This preliminary training usually required 3 to 5 weeks.

Discrimination training was begun immediately after the preliminary training was completed. Two discrimination problems were used, each involving a choice between two wood blocks, located 2 inches apart, one of which—the "correct" one—covered food. For the first problem, the blocks were painted to differ in brightness (black and white), and for the second, a different geometric pattern (circle and cross) was painted on the upper surface of each block. The animals were trained to perform the brightness problem first with one eye (eye 1), then with the other (eye 2). During this training, each animal was given 50 trials a day, one forelimb being restrained during the first 25 trials, the other during the remaining 25. The order in which the limbs were restrained was alternated from day to day. Training with a given eye was considered complete when the percentage of correct responses for either one of the forelimbs was above 90 for four consecutive days. Identical procedures were employed for the pattern problem, which was presented after completion of the brightness-discrimination training.

Table 1 shows the mean percentage of correct responses made by each of the three groups of animals on each problem with the forelimb homolateral to and the one contralateral to eye 1. The data for one of the animals in the split-brain group was excluded from the computations because the sectioning was found to be incomplete (*4*). It is evident that the difference between the means for the two forelimbs is small for each group on both problems. The data for individual subjects within each group reveal no systematic relationship between the eye used and forelimb performance, the homolateral forelimb being the superior in about as many animals as the contralateral. The largest difference between forelimbs, in terms of the percentage of correct responses, was 7, which was obtained for one of the normal animals on the brightness problem. During the course of learning, one forelimb was seldom consistently superior to the other. The results were very similar with respect to forelimb differential for eye 2.

The control animals reached criterion on the pattern problem with eye 2 in at least 82 percent fewer trials than with eye 1, whereas, in the split-brain group, the largest percentage reduction in trials to reach criterion was 19. The results suggest a similar difference between the control and the split-brain animals in degree of transfer of the brightness-discrimination learning but cannot be regarded as conclusive because several complicating factors were operating during this portion of the experiment.

These findings indicate that split-brain cats can respond appropriately with the homolateral forelimb to visual discrimination cues that are communicated only to one hemisphere. There are at least two ways to account for the results. First, there is the possibility of direct control of each limb through the homolateral cortex. Although, for example, most of the corticospinal fibers innervating a given limb originate in the contralateral cortex, there is evidence that a small portion originate in the homolateral (*5*). Another possibility is that the animal has a subcortical integrating system, somewhat similar to Penfield's hypothetical "centrencephalic system" (*6*), which receives sensory information from both sides of the body, and in which impulses controlling all the limbs originate. These findings also confirm the loss of interhemispheric transfer of visual pattern-

Table 1. Mean percentage of correct responses with the forelimb homolateral to and the one contralateral to eye 1 during brightness- and pattern-discrimination training.

Brightness problem		Pattern problem	
Homolateral forelimb	Contralateral forelimb	Homolateral forelimb	Contralateral forelimb
Normal animals			
76	77	72	75
Chiasm-section animals			
78	75	70	72
Split-brain animals			
74	74	73	69

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

discrimination learning in split-brain cats under a new type of training condition. The question of transfer of brightness-discrimination learning in these cats, which has not been studied before, requires further research.

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References and Notes

1. R. E. Myers, *Brain* 79, 358 (1956); R. W. Sperry, J. S. Stamm, N. Miner, *J. Comp. and Physiol. Psychol.* 49, 529 (1956); R. W. Sperry, *Anat. Record* 131, 297 (1958); J. L. deC. Downer, *Federation Proc.* 17, 37 (1958).
2. F. Hartmann, Jr., and W. Trendelenburg, *Z. ges. exptl. Med.* 54, 578 (1927); M. Kennard and J. W. Watts, *J. Nervous Mental Disease* 179, 159 (1934); A. J. Akelaitis has reported on a group of callosum-sectioned epileptic human beings in a series of papers [for example, *A.M.A. Arch. Neurol. Psychiat.* 45, 788 (1941); *J. Neuropathol.* 2, 226 (1943)]; see also K. U. Smith, *J. Comp. and Physiol. Psychol.* 45, 66 (1952).
3. This research was supported by NSF grant No. G-3880 to R. W. Sperry, and by the Frank P. Hixon Fund of California Institute of Technology.
4. At the end of the experiment, the brains of all the operated animals were fixed by perfusion with 10 percent formalin. In most cases macroscopic examination was sufficient to establish the extent of the sectioning. The posterior quarter of the callosum and, roughly, the posterior eighth of the chiasm were found to be intact in the animal eliminated from the split-brain group. This animal had shown a high degree of transfer on both problems.
5. A. M. Lassek, *The Pyramidal Tract* (Thomas, Springfield, Ill., 1954).
6. W. Penfield, *Brain* 77, 1 (1954).

7 January 1959

Weathering of Fallout

Abstract. Subjected to weathering by electrodialysis, fallout pellets collected after a nuclear explosion from the area near ground zero released trace amounts of their total beta activity. Airborne fallout collected 612 miles from the test site released 51.8 percent of its Sr^{90} activity. Aircraft-collected fallout released 40.5 percent of its Sr^{90} activity when collected from a tower shot and 86 percent when collected from a balloon shot.

The weathering rate of fallout is of interest because natural decomposition would be the first step in the potential assimilation of fallout and would also be the index to its rate of movement into the biological cycle.

The first set of samples was collected from the surface soil of the Nevada testing site. Fallout of this type has been described by Nishita and Larson (*1*). The particles appear to be glassy and spherical. Most of the particles were larger than 50 μ in diameter. A few ranged up to 2 mm in diameter. The particles used in this study were of sand size (0.05 to 1.0 mm) and were collected from contaminated sand with tweezers.

The second set was collected at Los Alamos, N.M., 612 air miles from the test site. An environmental air sampler equipped with a respiration filter pad was used. The activity build-up occurred 24 hours after a nuclear detonation. The third set was collected in pure cellulose filters that were mounted on aircraft which flew at an altitude of approximately 20,000 ft through the cloud from a nuclear detonation.

Duplicate samples of glass pellets were weighed (50 mg) and placed in small polyethylene bottles, and 12.5 ml of ground water was added. The samples were agitated by shaking intermittently during a period of 8 days, after which the liquid was removed by filtration and the gross beta activity of the liquid determined. The ground water was prepared like a soil saturation extract (*2*) except that porous Bandelier tuff was used instead of soil. The *p*H of the extract was 7.5. The cation content per liter was Na = 0.80 meq; K = 0.09 meq; Ca = 0.02 meq; and Mg = 0.05 meq. The principal anions present were bicarbonate, chloride, sulfate, and nitrate.

After filtration, the glass pellets were transferred back to the polyethylene bottles, and 10 ml of 1-percent ethylenediaminetetracetate (EDTA) (tech. grade, *p*H 10) was added. The samples were agitated by shaking intermittently during a period of 10 days, after which the supernatant liquid was removed and the gross beta activity of the liquid determined.

After the removal of the EDTA supernatant liquid, the pellets were transferred back to the polyethylene bottles and 10 ml of a suspension of H-clay was added. (Clay was removed from a sample of Ten Site soil by conventional methods and converted to the hydrogen system by mixing with H-exchange resin and then removing the resin from the clay with bolting silk. The *p*H of the resulting clay was 3.05.) The samples were agitated by shaking for a period of 10 days. Finally, the clay suspension was made 1*N* with ammonium acetate and centrifuged. The clear supernatant liquid was plated out, and the gross beta activity was determined.

The pellets were removed from the centrifuged clay by filtering through bolting silk and washing with distilled water. The pellets were then transferred back to the polyethylene bottles, and 10 ml of water plus 1 g of H-resin (Amberlite IR-120) was added. The samples were agitated by shaking for a period of 10 days. The mixture was made 1*N* with ammonium acetate and centrifuged. The clear supernatant liquid was plated out, and the gross beta activity was determined.

Table 1. Activity removed from glassy fallout pellets by different agents of weathering.

Agent	Gross beta activity present (10^5 count/min)	Activity removed (%)
Ground water (*p*H, 7.5)	2.17	0.01
EDTA (1%) (*p*H, 10)	2.17	1.08
H-Clay (*p*H, 3.04)	2.14	0.10
H-Resin (IR-120) (*p*H, 2.4)	2.14	2.40

The total gross beta activity of the fallout pellets was determined by counting samples of 50 mg each and taking the average, and by fusing and digesting 50-mg samples and determining the average count of a plated liquid aliquot of the sample. To determine the total Sr^{90} content of the glassy pellets, the samples were fused with Na_2CO_3 in the same manner as that used in analysis of silicate minerals. The Sr^{90} was isolated by ion exchange (*3*).

To study the effect of electrodialysis on the stability of the glass pellets, three fallout samples of 50 mg each were mixed with 100 g of uncontaminated soil. The mixture was placed in the dialysis chamber and dialyzed for 48 hours. The distance between the cathode and the anode electrodes was 2 cm (the voltage was maintained at 100). After dialysis, the extract was analyzed for Sr^{90} by the ion-exchange method.

To study the effect of electrodialysis on the stability of the samples collected

Table 2. Strontium-90 activity removed by electrodialysis from different types of fallout.

Type of fallout	Activity present (disintegration/min)	Removed (%)
Glass pellets Nevada test site	3,015 (per 50 mg)	Trace*
Los Alamos environment, collected by filter	1,547 (per sample)	51.8
Tower shot, collected by aircraft filter	38,780 (per sample)	40.5
Balloon shot, collected by aircraft filter	88,850 (per sample)	86.0

* Less than 5 disintegration/min.

at Los Alamos, three complete filter papers (obtained from the environmental air sampler) were placed in the center chamber of the electrodialysis cell. The samples were electrodialyzed for a period of 48 hours. The distance between electrodes was 2 cm. The voltage was maintained at 100 v. After the dialysis, the extract obtained was analyzed for Sr^{90} by the ion-exchange method (*3*). The filter papers were allowed to dry. They were then placed in a large porcelain crucible and heated slowly to 450°C and held at this temperature until they were ashed. The samples were allowed to cool to room temperature, then 10 ml of 72-percent perchloric acid was added to complete the digestion. The amount of Sr^{90} obtained by ashing the papers was determined by the ion-exchange method (*3*).

To study the effect of electrodialysis on the stability of the fallout collected by aircraft, approximately 2 cm^2 of the collector filter paper was placed in the dialysis cell and dialyzed for 48 hours. The conditions of dialysis were the same as those described above. The Sr^{90} of the dialysis extract and the portion remaining in the filter paper after dialysis were analyzed as described above. The results of the weathering studies of fallout are presented in Tables 1 and 2.

The results of this study show that the glassy pellets which fall in the area around the test site are resistant to weathering. They are so resistant that it is unlikely that more than 1 percent of their activity would enter into the biological cycle in any given year.

The samples collected at Los Alamos contained Sr^{90} in dialyzable and nondialyzable forms. This does not seem unreasonable since some of the glassy pellets are small enough to be transported by wind from the test site to Los Alamos.

The results of the study on the samples collected by aircraft flying through the cloud caused by the nuclear detonation suggest that electrodialysis could be used to evaluate the hazard associated with each type of detonation and that valuable information regarding the rate of entry into the biosphere could be obtained.

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10 November 1958

Group Effort in Modern Physics Research

Abstract. In the *Physical Review* for the year 1957, as a sample, multiple authorship appears with greatest relative frequency in communications from government, academic, and industrial laboratories, in that order. For the three types, it appears that research is conducted on the average by groups and not by individuals. These conclusions are at variance with premises assumed recently by R. S. Uhrbrock (*1*).

For the planning and direction of scientific research, it is important to determine the elusive factors that enter into research productivity. The elements affecting the productivity of the *individual* have been studied recently by Shockley (*2*). However, current scientific periodicals show that articles with N authors, where N not infrequently is large relative to unity, are prevalent, whereas such papers were the glaring exception a decade or so ago. It is interesting to examine quantitatively the relative frequency of group and individual efforts in the physical sciences and to determine whether any correlations exist. This report summarizes initial conclusions for one science, physics, based on a sample consisting of all contributions that appeared in the *Physical Review* during the calendar year 1957 (volumes 105–108). This particular journal was selected because of its timeliness in the coverage of active areas of research in modern physics.

In the sample chosen, the names of laboratories of three general types (academic, government, and industrial) appear in the respective by-lines of the contributions (*3*). For each separate category the histogram given in Fig. 1 shows the total number (on a logarithmic scale) of papers and letters to the editor with N authors (*4*) as a function of N. The most striking feature revealed by Fig. 1 is that the number of communications with N greater than unity is relatively, as well as absolutely, greater for government and academic laboratories than for their industrial counterparts. This number is 64, 62, and 48 percent, respectively, of the total number of communications in the three categories, listed in the order given above. Thus, only for industrial laboratories are contributions from single authors not outnumbered by those of joint authorship.

An individual rank in its category was assigned to each laboratory, corresponding to the total number of communications from that laboratory in the sample. In the academic category, the University of California, Berkeley, ranks first, with 112 works; Bell Telephone Laboratories is the corresponding giant (47 works) in the industrial class. The histogram given in Fig. 2 shows the average number of authors per contribution from a laboratory as a function of rank for academic and industrial laboratories, up to rank 50 (three works) for the former. One sees immediately that for the laboratories under consideration, research is conducted, in general, by groups or teams and *not* by individuals. In fact, the mean number of authors per publication over the entire sample considered is 2.1, 2.1, and 1.7 for academic, government, and industrial laboratories, respectively. Comments by Temperley (*5*) indicate that a trend toward a similar situation exists in the United Kingdom.

The conclusions given above are not at all what widely held preconceptions might suggest. It is true that the choice of a different journal of physics would alter conclusions with respect to details (the papers of Fig. 1 with an extremely large multiplicity of authors are all on nuclear physics). Clearly, however, the ubiquity of group effort is the ineluctable concomitant of the explosive growth of

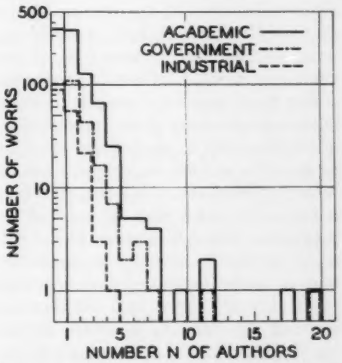

Fig. 1. Number of research communications with N authors in the sample, as a function of the number, N, of authors (the vertical scale is logarithmic).

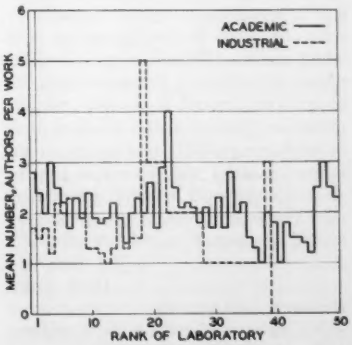

Fig. 2. Mean number of authors per research communication from a laboratory, as a function of the laboratory's rank in research productivity. (Results for government laboratories have been omitted for the sake of simplicity.)

science in recent times, with its consequent dependence on the services of specialists and the functioning of large (sometimes vast) complexes of equipment. An interesting question which has not been explored is the secular dependence of multiple authorship on time; are the papers today with 20 or so authors, as indicated in Fig. 1, merely the precursors of papers with 50 or 100 authors that will appear some decades hence?

A guest editorial by Uhrbrock (*1*) in *Science* is germane to the results of this study. Uhrbrock's conclusions are based on the following premises: (i) Research in industrial laboratories is conducted mainly by teams of investigators, and (ii) investigation by teams is in some sense inimical to the proper ends of science and to the best interests of the individual investigator. At least for the sample studied in this report, it is clear that premise (i) is not restricted to industrial laboratories but is valid a fortiori for academic and government laboratories, on the logical assumption that any number of authors in excess of one constitutes a team (the dictionary definition). In view of the stature of the *Physical Review* in its field, it would appear, further, that premise (ii) is not valid in general. Uhrbrock's conclusion is that the prospective investigator in an industrial laboratory should protect himself against the danger of the team by means of a written statement obtained before employment. However, the correlation with joint effort of rank of institution in research productivity, as implied in Fig. 2, suggests the possibility that in many laboratories such a step might defeat its own end. Without examining the numbers involved, Shockley (*6*) has taken issue on essentially the same grounds with views of Miessner (*6*) similar to those of Uhrbrock.

Contrary to a possible implication in Uhrbrock's discussion, 172 communications in the sample studied attest to a basic willingness on the part of industrial laboratories to publish research results. At least in the laboratory with which we are affiliated, approval of the patent department (approval which has never been denied) is the only requirement for submission of a finished piece of work for publication (as against the time-consuming and uncertain security clearance required in many government laboratories and research enterprises conducted by universities and institutes) (*7*).

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3. The designation *government* includes laboratories operated by a national government or operated for it by universities or industrial contractors. Foreign "institutes of physics" were classed as academic.
4. In cases where the names of laboratories of more than one category appeared in a by-line, prorated fractions were assigned to the number of communications from each category for that value of *N*. In Fig. 1, the resulting numbers were rounded to the closest integer above.
5. H. N. V. Temperley, *Science* **124**, 355 (1956).
6. B. L. Miessner and W. Shockley, *Proc. I.R.E.* (*Inst. Radio Engrs.*) **45**, 409 (1957).
7. We wish to acknowledge discussions with Dr. W. Zeit of the School of Medicine of Marquette University, and to thank Miss H. Pandow for the computational work.

23 January 1959

I have no desire to prolong the discussion of the effects of team membership on the scientific careers of individuals employed in industrial laboratories. Gilvarry and Ihrig have presented data showing that multiple authorship is increasing in the field of physics. Smith [*Am. Psychologist* **13**, 596 (1958)] reported a similar trend in psychology. These studies show that (i) team research is being conducted on an increasingly large scale in governmental, academic, and industrial laboratories, and (ii) *some* teams are reporting their results, listing two to 20 persons as collaborators.

We have no evidence about the number of teams in existence at any one time or any indication of the proportion of completed projects reported. Young scientists should be aware of the trend toward team research and should consider its possible effect upon their individual careers. The time to ask questions is before accepting employment. That, as simply as I can state it, is the point I wish to emphasize.

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6 February 1959

Enchytraeus fragmentosus, a New Species of Naturally Fragmenting Oligochaete Worm

Abstract. A new species of enchytraeid (Oligochaeta) worm has no sex organs, but reproduces solely by fragmentation.

In April 1956 I received from R. A. Didriksen of Iowa State College some fresh enchytraeid worms, believed to be *Enchytraeus albidus*. Careful investigation, whole-mount and serial section studies, revealed that the culture was a mixture of two species, the one being *Enchytraeus fonteinensis* Michaelsen (1927), the other of uncertain classification. The separate cultures have been going for over 2 years, the *E. fonteinensis* reproducing from cocoon to cocoon about every 10 days, the other species reproducing by fragmentation in about the same length of time.

The amazing thing about the second species is the phenomenon of fragmentation. Fully mature worms break into from 3 to 11 fragments, usually of about five segments each. Each portion fully regenerates in a period of about 10 days. There is every reason to believe that full regeneration of vital structures results from changes of undifferentiated tissues of the body; I have not undertaken such an investigation, but have noted unusual, large "formative" cells in the body cavity.

Since the material lends itself to a great number of investigations—for example, regeneration processes; gradients, polarity and reversal of polarity; radiation experiments; possible mutations; pharmacological investigations—I offer to supply living material at postage cost to any applicants.

Enchytraeus fragmentosus n. sp. Because these worms have no sex organs, the usual criteria for determination of species, other characteristics will have to be adduced for diagnosis. Before I was aware of the unusual reproductive method in this worm (to my knowledge it is exceptional for all oligochaete worms), I regarded the worm as an immature specimen of *E. albidus*. The peptonephridia come from a dorsal pouch in segment III and divide into two sac-like masses passing caudad and ventrad in segment IV as in *E. albidus*. There are, however, a number of twigs off the main sacs in segment IV. There is one outstanding difference in the new species—namely, the possession of four pairs of septal glands instead of the usual three pairs. The type specimen is in my collection.

Diagnosis: Color white; length 10 to 16 mm in crawling; segments about 50 when fully developed; diameter 0.25 mm; setae straight, two only per fascicle; no special glands; no clitellum; prostomium rounded; head pore at 0/I. Brain nearly round, concave anteriorly and indented posteriorly, 65 μ wide and long. Pharynx in segment III with typical high palisade cells in roof; oesophagus widens gradually, no oesophageal pouches; peptonephridia arise in segment III from a dorsal pouch and branch into two elongated sacs in segment IV, with a number of terminal twigs. Chloragog cells large without granules. Septal glands (pharyngeal glands) lie on septa IV/V, V/VI, VI/VII, and VII/VIII. Dorsal vessel arises in segment XIII. Coelomocytes (lymphocytes) with clear, loose cytoplasm and large nucleus; circular; 15 to 20 μ in diameter; appear to be amoeboid in the living. Nephridia with small preseptal (20 μ long, 10 μ wide); postseptal larger (50 μ long, 20 μ wide) with terminal duct. No sex organs: reproduction solely by fragmentation.

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17 December 1958

"Attention" Units in the Auditory Cortex

Abstract. In the course of examining single unit responses from the cortex of unrestrained and unanesthetized cats, we have come upon a population of cells that appears to be sensitive to auditory stimuli only if the cat "pays attention" to the sound source. We have described these responses, since they have not been previously reported and since they illustrate an important difference between the information which can be gleaned from experiments of this type and that obtained in the usual "acute" microelectrode experiment.

Cortical units that seem to be sensitive to auditory stimuli only if the subject "pays attention" were encountered in a series of experiments carried out on the auditory cortex of seven cats. The recording technique has already been summarized (*1*) and was as follows. Animals were prepared under anesthesia, with a small hollow plastic peg screwed into the skull over the cortical site to be examined. Several days later this peg was used to hold a hydraulic micropositioner containing a tungsten microelectrode (*2*). At the end of each recording session the holder and electrode were removed, and the cat was returned to its cage. The cats were studied for many hours during each of four to six recording sessions carried out over a period of 7 to 14 days. In each recording session the units were examined for periods of up to several hours, during which time the cat was free to move its head, groom, sleep, and so on.

Electrode sites were verified by marking the brain through the lumen of the peg with India ink, perfusing the cat with 10-percent formalin, and removing and photographing the brain. In this series of experiments it was not possible to measure the depth of the electrode accurately at the time of recording. All units, however, were located 5 mm or less beneath the cortical surface. From previous work (*2*) it is known that the electrodes used are capable of recording both from cell bodies and from myelinated fibers, but it was not possible to distinguish one from the other in these studies. Loud-speakers located near the cat's head were used to deliver the auditory stimuli. The frequency range from 50 to 50,000 cy/sec was adequately covered.

The following extracts from the protocol illustrate the peculiar behavior of these cells.

Cat 17. This unit studied for 1 hr 35 min showed little spontaneous activity. It could not be reliably driven by clicks, tones, or noise from the loud-speaker on repeated tests, although a new tone or noise might evoke responses during the first few presentations. When the experimenter entered the experimental room he discovered that a variety of natural stimuli could evoke responses provided the cat appeared to be paying attention to them. The unit responded briskly, for example, to (i) voice, (ii) squeaks emitted by squeezing a toy rubber mouse [Fig. 1], (iii) scratching fingernail on table nearby, (iv) hissing, (v) tapping the table. It responded regularly and consistently to clicks from the loud-speaker whenever the experimenter pretended to tap the loud-speaker in rhythm with the clicks but without actually making any sound. Passively closing the cat's eyes with the fingers did not stop the response when it was present. Discharge rate seemed to vary with the intensity of the stimulus and response frequently outlasted the stimulus by periods of up to about one second.

Cat 18. This unit was spontaneously active but could not be driven by clicks, tones, or noise from the loud-speaker. Keys jingled by the experimenters outside the room in which the cat was isolated evoked responses when the animal looked toward the door, but not otherwise. The experimenter then entered the room, picked up a small piece of paper between each thumb and forefinger and held his hands to the right and left of the cat about 12 inches away from its ears. When the paper was rustled in the right hand no response occurred until the cat looked toward it, whereupon a large burst of firing occurred so long as the sound was produced. If now the paper in the left hand was rubbed, nothing happened until the cat turned its head in that direction, whereupon again the unit responded to the sound. If the noise was made to alternate between left and right hands, responses occurred only to the sound produced by the hand toward which the cat was looking. Holding the hands out of sight did not change the result: so long as the cat looked in the proper direction the responses occurred. The unit was studied in this way for many minutes.

Six units of the sort just described were seen in four cats. At least nine other units, somewhat less intensively studied, should probably also be included, for they responded poorly or not at all to clicks, tones, or noise from the loud-speakers but responded well to sounds produced near the animal. Since the total number of units thus far studied is more than 100, about 10 percent can therefore be called attention units. As for the remaining 90 percent, it is not our purpose to discuss the behavior of these units in detail here, but it should be pointed out that some of them responded reliably for long periods to stimuli presented by means of the loud-speakers, regardless of the behavioral state of the animal (alert, asleep, and so on). Furthermore, one well-studied unit (in cat No. 24) was exquisitely responsive to 53-kcy/sec sound, from which we infer that our failure to drive other units with tones was not due to failure to generate high-frequency sounds. Finally, it has proved impossible to discover the stimuli adequate for driving many of our cortical units, a fact we cannot readily explain.

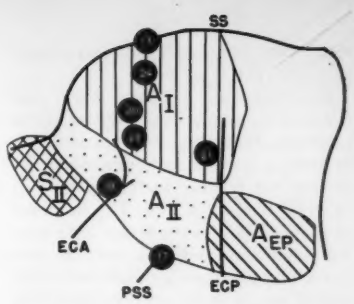

Fig. 2. Schematic drawing of the left auditory cortex of the cat, showing the location of electrode tracks in seven cats. A_I, A_{II}, and A_{EP} are the main auditory cortical areas.

The cortical loci thus far explored include A_I and A_{II} and their rostral and inferior borders with adjacent cortex (Fig. 2). Five punctures (cats Nos. 13, 20, 22, and 24) in approximately the center of A_I yielded no attention units, while three others (cats Nos. 13 and 24) did. In cats Nos. 17 and 18, where most attention units were found, cortex just in or just out of A_I and A_{II} seems to have been entered. The material, however, is still too scanty for us to settle the question of just where attention units occur in and near the auditory cortex.

We have in four punctures (three cats) encountered both attention units and conventional responders in a single electrode penetration. In three separate penetrations in cat No. 17, however, we encountered only attention units, or units not driven by the loud-speaker stimuli. These facts would make it appear that attention units are both interspersed among conventional responders and collected in isolation apart from

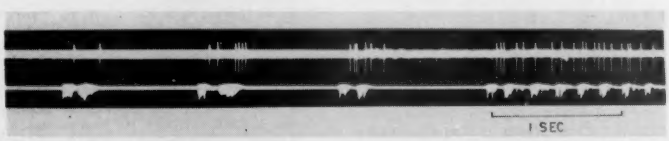

Fig. 1. Response of an auditory cortical unit in cat No. 17. Lower line shows response of a microphone located near the cat's ear; the deflections seen there were produced by squeaks emitted when a toy mouse was squeezed. The upper line shows the unit responding to the squeaks to which the animal was paying attention; this unit almost never responded to clicks, tones, or noise from a nearby loud-speaker.

them, but, again, this problem cannot be considered as settled.

According to Erulkar, Rose, and Davies (*3*), 34 percent of the units isolated in auditory cortex cannot be driven by sounds, and, in fact, only about 14 percent are reliably and securely activated by acoustic stimuli. The cats used by these workers were under light general anesthesia, and so it may be presumed that the attention units under discussion here were included in their class of nonresponders. It is not easy to understand why the auditory cortex, in the anesthetized or intact cat, should be populated with so many cells that fail to respond to auditory stimuli. Perhaps these cells become activated only when certain other conditions are simultaneously met. Thus, from our data one may conclude that the neural processes responsible for attention play an important role in determining whether or not a given acoustic stimulus proves adequate. Unfortunately attention is an elusive variable that no one has as yet been able to quantify. It may be that studies in which cortical unit activity is examined during the course of conditioning and learning will illuminate these matters.

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28 November 1958

Distribution of Radioactivity in Wheat Plants Grown in the Presence of Strontium-90

Abstract. Thatcher wheat grown in soil to which Sr^{90} had been added showed that accumulation of radioactivity in the kernels was about one-tenth the accumulation in leaves and stems. Experimental milling of the kernels gave brans with the largest amounts and flours with the least amounts of activity, the Sr^{90} concentrations being related practically linearly to the weights of total ash in the various milling products.

Because of the current interest in the possible contamination of plant products by strontium-90 from fallout from nuclear explosions, a study was made of the distribution of Sr^{90} absorbed from the soil by wheat plants (*1*). Single plants of the Thatcher variety were grown in individual pots in the greenhouse. Each pot contained 450 g of Saskatchewan Oxbow loam soil, the analysis of which showed 19.2, 6.5, 1.9, and 0.1 milliequivalents of exchangeable Ca, Mg, K, and Na, respectively, per 100 g of soil. The soil moisture was kept at its field capacity of 35 percent by daily watering throughout the period of growth of the plants. At various stages of growth, an aliquot of 1, 2, or 3 ml of a solution of $SrCl_2 \cdot 6H_2O$ (0.1 mg/ml) with Sr^{90} activity of about 2.5×10^6 count/min ml was added to the soil in each pot. The plants were harvested at maturity and separated into kernels, heads, leaves, and stems. Some of the kernels were reserved for milling studies. The remaining fractions, each containing 5.0 mg of added inactive strontium chloride as carrier, were wet-ashed with concentrated sulfuric acid and perchloric acid.

After practically all the excess mineral acids had been evaporated off, each residue was taken up in water, neutralized, and made slightly basic before the strontium was precipitated as strontium phosphate. The precipitate was collected by centrifugation, transferred to a sample pan, and dried, and the activity was counted. Standard samples were prepared in the same way by wet-ashing fractions of nonradioactive wheat to which known quantities of Sr^{90} were added. From such standard samples, the Sr^{90} activity originally introduced into the soil was ascertained, and the uptake of Sr^{90} by various parts of the wheat plant was calculated. The results, summarized in Table 1, indicated that under the conditions of these experiments, the accumulation of Sr^{90} in the kernels was only a few thousandths of 1 percent of the amount added to the soil, while the uptake by the leaves or stems was about ten times as high as the uptake by the kernels. This is in agreement with findings of other workers (*2*) that Sr^{90} taken up from the soil by various types of plants generally appeared in high concentration in leaf tissues and in low concentration in seeds.

It is of interest to determine what portion of the Sr^{90} in the wheat kernels would appear in flour, the product consumed by man. Two crops of kernels from these experiments, each weighing about 7 g, were experimentally milled to give flour, shorts, and bran. The mill used was one similar to that described by Geddes and Frisell (*3*). The radioactivity and ash of the three milled fractions from each crop were measured. The flours contained 9 and 16 percent, the shorts, 29 and 31 percent, and the brans, 62 and 53 percent, respectively, of the total activity of the two crops. Though the flour fraction had the highest weight, it contained the least radioactivity. The largest portion of the activity was found in the bran. This is not surprising since the bran has the highest level of mineral matter, as is indicated by its ash content. Actually, there was a direct relationship between Sr^{90} activity and total ash in the milling product—namely, the higher the total ash, the greater the Sr^{90} concentration (Fig. 1). One of the criteria of a high-grade patent flour is its low ash content. The results given here would indicate that one may reasonably expect that possible contamination by Sr^{90} from uptake of fallout debris should be lower for higher-grade flours.

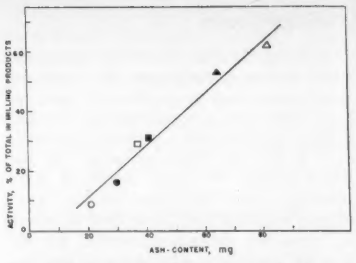

Fig. 1. Relationship between total ash and Sr^{90} concentration in milling products of Thatcher wheat. Circles, squares, and triangles represent flours, shorts, and brans, respectively—open symbols, crop 1; closed symbols, crop 2.

Table 1. Uptakes of Sr^{90} by various parts of Thatcher wheat.

Duration of Sr^{90} in soil before harvest (days)	Av. uptake of added activity (10^{-3} percent)			
	Kernels	Heads	Leaves	Stems
73*	2.9	2.3	30	14
73†	2.2	1.4	19	10
44‡	1.6	2.0	21	38
29‡	1.1	2.5	9.5	33

* 1 ml of Sr^{90} solution added per plant.
† 2 ml of Sr^{90} solution added per plant.
‡ 3 ml of Sr^{90} solution added per plant.

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1 December 1958

Paradoxical Action of Solvents on Bacterial and Liver β-Glucuronidases

Abstract. Dichloromethane and chloroform have been found to inhibit the action of liver β-glucuronidase on phenolphthalein glucuronic acid at concentrations which produce a considerable enhancement of bacterial β-glucuronidase. Other solvents, including *n*-butanol, benzene, and toluene, have very little effect on the liver enzyme but nevertheless potentiate the bacterial enzyme.

Increased information concerning conjugation with glucuronic acid has aroused considerable interest in the problem of hydrolysis of conjugated steroids in blood and urine. Commercial preparations of highly active β-glucuronidase from mammalian liver and bacteria are available for the treatment of biological materials to liberate conjugated steroids. Such enzymes usually yield more consistent results than acid hydrolysis does. Combination of hydrolysis with prior and subsequent extraction with appropriate solvents permits determination of free and conjugated materials.

In this laboratory, recent studies on the hydrolysis and extraction of adrenal cortical steroids from plasma yielded variable recoveries and even an occasional apparent absence of conjugated forms when liver β-glucuronidase was employed. A recent bulletin issued by the Sigma Chemical Company (*1*) called attention to a remarkable potentiation of bacterial β-glucuronidase activity by chloroform. Since dichloromethane was regularly employed in our procedure, it was thought worth while to study the effects of this and other solvents on both types of β-glucuronidase.

In the present study (*2*), we used the method of Talalay, Fishman, and Huggins (*3*) with phenolphthalein glucuronic acid as substrate for the assay of glucuronidase activity. The enzymes employed were liver β-glucuronidase (Ketodase, Warner-Chilcott, *4*) and bacterial β-glucuronidase (Sigma). For measuring the effect of various solvents on bacterial glucuronidase activity, the digestion medium consisted of 4 ml of 0.075*M* phosphate buffer at *p*H 6.8, 0.5 ml of 0.01*M* phenolphthalein glucuronide, 0.1 ml of solvent, and 0.5 ml of the enzyme preparation containing approximately 25 Fishman units. For controls, the solvent was replaced by an equal volume of buffer. After digestion for 1 hour at 37°C, the reaction was stopped by the addition of 5 ml of 0.40*M* glycine buffer at *p*H 10.45. The effect of solvents on liver β-glucuronidase activity was evaluated in the same manner as the effect on the bacterial enzyme, except that 0.1*M* acetate buffer (*p*H 4.5) was used as part of the digestion medium rather than phosphate buffer. Blanks containing the buffer and the enzyme were included; the substrate solution was added after termination of the digestion period and addition of the glycine buffer. The amount of phenolphthalein liberated by the enzyme reaction was calculated from the optical density of standards at 540 mμ.

Table 1 shows the results obtained with each solvent, referred to the control activity (about 25 units) as 100 percent. There is a marked difference in response of the two enzyme preparations since most of the added compounds, except methanol and hexane, potentiated the bacterial but not the liver enzyme. Dichloromethane and chloroform were moderately potent inhibitors of the liver enzyme, dropping activity to 28 and 71 percent of controls, respectively, while more than doubling that of the bacterial preparation.

Although methyl and ethyl alcohols had little effect on the bacterial β-glucuronidase, the most marked enhancement of all was seen with propyl, butyl, and amyl alcohols, the last amounting to 817 percent. Three chlorinated hydrocarbons—dichloromethane, chloroform and ethylene dichloride—doubled or tripled the activity of bacterial β-glucuronidase. Carbon tetrachloride, benzene, and toluene nearly doubled it.

Our results emphasize the difference between two available β-glucuronidase preparations when studied under comparable conditions. Both have been employed in the hydrolysis of conjugated steroids for endocrine assay although it has previously been noted that the bacterial enzyme is less reliable than the liver in the presence of plasma proteins. The remarkable enhancement produced by butanol may make the former more useful under such circumstances. On the other hand, the 72-percent inhibition of liver β-glucuronidase by dichloromethane eliminates the use of this solvent for extraction prior to hydrolysis, and attention must be paid to the possibility that other organic compounds commonly used may depress the liver enzyme enough to interfere with its use.

The theoretical implications of these results are also important. The work of Bernfeld, Jacobson, and Bernfeld (*5*) showed that inactivation of liver β-glucuronidase by dilution or by addition of such macromolecular polyanions as polymethacrylic acid could be reversed by albumin and DNA. The possibility that the bacterial β-glucuronidase as obtained is made up largely of dissociated or inhibited forms which are reactivated in our experiments has not been substantiated in trials with albumin and DNA. The varied chemical nature of our "activators" (aromatic hydrocarbons, chlorinated aliphatic hydrocarbons, and aliphatic alcohols) also makes this explanation seem unlikely. Fishman and Green (*6*) reported transferase activity associated with glucuronidase when certain alcohols were present during the incubation. Since we measured phenolphthalein liberated rather than free glucuronic acid, transfer of the glucuronic acid moiety to butanol might have occurred. The fact that the greatest enhancement was obtained with the highest alcohol tried (amyl) is also suggestive of esterification. It remains to be seen whether the enhanced glucuronidase activity is as great with a conjugated steroid as it is with phenolphthalein glucuronic acid.

In the case of the nonalcoholic hydrocarbons, ester formation cannot explain the potentiation. Since the 0.1-ml portions used here did not always go completely into solution, a small solvent second phase was often present. Visual inspection did not support any preferential extraction of liberated phenolphthalein. There remains the possibility of extraction of an inhibitor from the bacterial β-glucuronidase.

Table 1. Effect of various solvents on activity of liver and bacterial β-glucuronidases. Each substance was added in 0.1 ml quantity; results are shown in terms of percentage of control enzyme activity (25 ± 2 Fishman units).

Solvent	Source of enzyme	
	Liver	Bacteria
Dichloromethane	28	249
Chloroform	71	271
Carbon tetrachloride	105	188
Ethylene dichloride	83	269
n-Hexane	79	107
Benzene	83	198
Toluene	92	180
Methyl alcohol	99	116
Ethyl alcohol	83	129
n-Propyl alcohol	100	258
n-Butyl alcohol	92	585
n-Amyl alcohol	99	817

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2. This work was supported in part by a grant from the National Institute for Arthritis and Metabolic Diseases.
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8 December 1958

National Academy of Sciences

Abstracts of Papers Presented at the 96th Annual Meeting, 27–29 April 1959, Washington, D.C.

Obscurations of Lunar Features

During the past couple of centuries many unverified reports of lunar haze have been published by amateurs, many of whom were experienced observers. Most discussed were the floor of Plato and the bright mound, Linne. A Lick Observatory photograph (26 Oct. 1937) showed the floors of Ptolemaeus, Alphonsus, and Flamarion as "milky." This may have been only photographic illusion. Because of these reports a program was planned to secure pairs of plates at widely different wavelengths by means of the 60-inch reflector at Mt. Wilson.

Such observations have been carried on since April 1954. On 26 Oct. 1956 rather strong positive evidence was secured within Alphonsus. As a result, N. A. Kozyrev, at the Crimean Observatory, made systematic spectrographic observations and on 3 Nov. 1958 secured the strongest positive evidence to date. An interpretation of his results is included in this paper. Systematic observations of all suspicious areas of the moon must be carried out, all known methods being used to secure them.

DINSMORE ALTER
Griffith Observatory and Aeronautics Systems

Solution of the Main Problem of Artificial Satellite Theory

The principal part of the motion of the argument of the perigee of an artificial satellite contains the factor $-1+5\cos^2 I$, I being the inclination of the satellite's orbital plane with the earth's equator. This factor again appears as a divisor in the coefficients of certain periodic terms. This divisor is zero for the critical inclination, $I_c = 63°26'$; hence, this type of representation of the motion becomes illusory for orbits with inclinations within a few degrees of the critical inclination.

The difficulty is overcome by making use of a method in canonical variables that is equivalent to the method used by Delaunay in the lunar theory. Actually, the procedure is similar to that employed by H. v. Zeipel (*Arkiv. Mat. Astron. Fysik* 11, 1, 1916) in a qualitative study of planetary perturbation theory. The core of the method is choosing a transformation of variables such that the argument of the perigee is the only angular variable present in the transformed Hamiltonian. The system is thereby reduced to 1 degree of freedom; it can be solved completely by well-known procedures.

A significant feature of the method is that, to the degree of accuracy required for current practical needs, the solution is achieved in closed form, valid for any eccentricity of less than unity and for any inclination.

DIRK BROUWER
Yale University Observatory

Morphologic and Metabolic Changes Produced in Rat Adipose Tissue in Vitro by Insulin

Addition of insulin to the rat epididymal fat pad incubated in vitro in bicarbonate-buffered media markedly stimulates the uptake of glucose and its conversion to fat. This effect is readily observed by measuring manometrically the increased CO_2 output that accompanies fat synthesis. Using this procedure to monitor the effect, we made preliminary studies with the electron microscope of the accompanying morphologic changes at different insulin and glucose concentrations and with different incubation periods.

For example, 20 minutes after the addition of insulin (10^{-3} units per milliliter), a definite metabolic change has occurred, and tissue taken for examination at this time shows characteristic morphologic changes. Whereas control tissue incubated without insulin showed a rather dense granular cytoplasm in which the population of organelles was sparse, the cytoplasm of tissue incubated with insulin showed a loss of granularity in the cytoplasm and the development of a system of membrane-bound vesicles that, at the plasma membrane, appeared as pinocytotic invagination and pinched-off vesicles. Deeper in the cytoplasm a seemingly continuous system of smooth, large-membrane–bounded vesicles or canalicular channels had developed. Lipide droplets were present in the cytoplasm. Although minute pinocytotic vesicles were occasionally found bordering the plasma membrane of tissue incubated without insulin, no membranous systems of vesicles or channels were found.

We tentatively suggest that one of the actions of insulin is to stimulate pinocytosis, which brings about the described morphologic changes, and that as a consequence, alterations in the properties of the membrane occur which make it more permeable to certain molecules—for example, glucose. Such a concept of insulin action receives support from the rapid fixation of insulin to tissue first observed by Stadie *et al.*, and from the experiments of Levine, Park, and others on the effect of insulin on cell permeability.

RUSSELL J. BARRNETT, ERIC G. BALL
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Vacuum Polarization and Screening Effects in Scattering from Heavy Nuclei

In order to facilitate geometry calibrations of proton-proton scattering experiments by scattering of protons by nuclei and as a matter of general interest, effects of the vacuum polarization have been calculated and compared with screening by electrons. In Uehling's approximation the vacuum polarization appears as a superposition of Yukawa terms for which the scattering amplitude is expressible by means of the hypergeometric function suitable for computation and can be rearranged in series with Bessel functions of imaginary argument $K_n(x)$ in coefficients of incident momentum. This expansion is related to the classical orbit view shown to furnish a fair approximation.

Classically, the quantity x is the eccentricity of the orbit times half the minimum distance of closest approach times the reciprocal range constant of the potential. The vacuum polarization scattering is obtained by superposing amplitudes for Yukawa potentials. The results can be represented approximately by a universal curve relating $z_1 z_2/[E_{lab} \sin(\theta/2)]$, in usual notation, to the fractional change in the differential cross section. For $\theta = 10°$ and energies 3 and 1.5 Mev, proton-argon scattering effects of 0.272 and 0.116 percent, respectively, and for alpha-lead scattering at $\theta = 5°$ and 21.95 Mev, a vacuum polarization effect of 0.080 percent, are found. In the latter case the screening effect is -0.6 percent. For proton-xenon, 9 Mev, 10°, the screening effect is -0.28 percent, comparable with the vacuum polarization effect. Precision tests of vacuum polarization action for fundamental theory are complicated by the presence of screening potential.

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A Long-lived Carbonium Ion Intermediate in a Molecular Rearrangement

On the basis of evidence which is extensive and consistent but indirect, numerous molecular rearrangements have long been known to proceed by way of

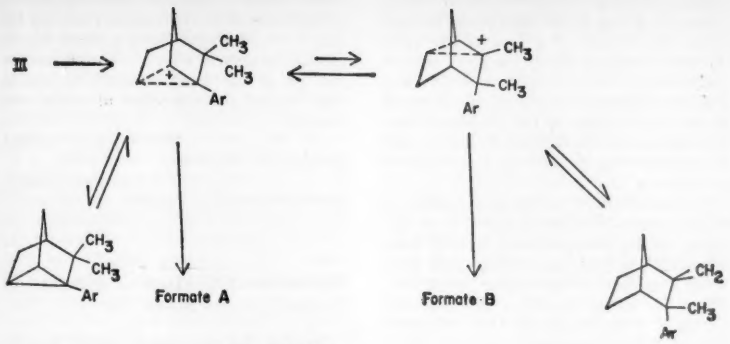
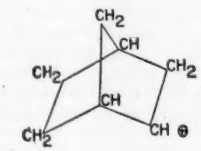
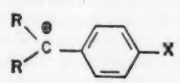


Fig. 1

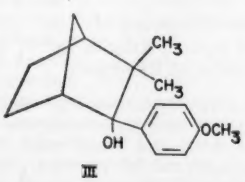
carbonium ions (molecular species bearing a positive charge on a carbon atom or distributed over a group of carbon atoms). There are several structural features which enhance the stability of carbonium ions, among them the occurrence of the charge at the 2-position of a bicycloheptane ring (I) or in the alpha position of a side chain attached to a benzene nucleus (II).



I



II



III

In *p*-anisylcamphenilol (III) the hydroxyl group is at the 2-position of a bicycloheptane ring and is also in the alpha position of a substituted benzene containing the activating methoxy group. This compound dissolves in formic and hydrochloric as well as in sulfuric acid with the formation of electrically conducting solutions with intense absorption in the near ultraviolet ($\gamma_{max} = 384$ mμ, log $\varepsilon = 4.7$). These solutions yield a series of products of the sort commonly produced in the Wagner-Meerwein rearrangement. Kinetic analysis of the rate of decline of optical absorption or of conductivity in formic acid leads to the description of the initial reactions shown schematically (Fig. 1).

Optically active starting materials yield a series of products whose optical activity rules out the occurrence of symmetrical intermediates and indicates a series of extensive changes on prolonged standing of the solutions.

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Effect of Spin and Speed on the Lateral Deflection of a Baseball; Magnus Effect for Smooth Spheres

The effect of spin and speed on the lateral deflection (curve) of a baseball has been measured by dropping the ball while spinning about a vertical axis through the horizontal wind stream of a 6-foot tunnel. For speeds up to 150 ft/sec and spins up to 1800 rev/min, the lateral deflection was found to be proportional to the spin and to the square of the wind speed. When applied to a pitched ball in play, the *maximum* expected curvature ranges from 10 to 17 in., depending on the spin.

The deflections of rough baseballs accord in direction with that predicted by the Magnus effect. But with *smooth* balls at low speeds the deflection is in the *opposite* direction. This is studied with an apparatus specially designed to measure the pressure at any point in the equatorial plane of the rotating ball.

LYMAN J. BRIGGS
National Bureau of Standards

Ionic Membrane Current Measurements in the Squid Giant Axon

The measurement of the ionic current flow across the squid axon membrane in a "voltage clamp" has the two requirements that the membrane potential difference be uniform over the membrane area through which the current is measured and that it be constant for the duration of the current measurement after the change from the initial resting potential. These requirements prevent impulse propagation or initiation and are approached with low-resistance axial and external electrodes and powerful electronic control.

It has been found that the best axons, in condition to give their maximum responses and when the membrane potential is well controlled, usually produce ion current patterns that are of the type originally described by Cole and analyzed by Hodgkin and Huxley, though several times larger than these. The surface resistance of the axial electrode was found to be the most critical single factor, and the occasional obvious distortions of the current patterns are attributed to the marginal adequacy of this and the external electrodes. For axial electrode resistances but a few times larger than the best so far used, the membrane potential has been found not only to be inadequately controlled but also to behave in a manner that can be predicted by approximations of the Hodgkin and Huxley equations.

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R. E. TAYLOR
National Institutes of Health

Dependence of the Walden Product on Dielectric Constant

Analysis of conductance data for the following nine systems—(i) tetrabutylammonium bromide in dioxane-water mixtures, (ii) in methanol-carbon tetrachloride mixtures, and (iii) in nitrobenzene-carbon tetrachloride mixtures; (iv) tetrabutylammonium tetraphenylboride in acetonitrile-carbon tetrachloride mixtures and (v) in nitrobenzene-carbon tetrachloride mixtures; (vi) tetraethylammonium picrate in water-methanol mixtures; and tetrabutylammonium (vii) iodide, (viii) nitrate, and (ix) picrate in nitrobenzene-carbon tetrachloride mixtures—shows that the Walden product (limiting equivalent conductance times viscosity) varies in a systematic way with solvent composition. The effect is shown to be electrostatic in origin: A one-to-one correlation exists between the Walden product and the dielectric constant D of the solvent, regardless of the nature of the dependence of viscosity on composition (increasing, decreasing, and so on).

On the assumption that the transference members of both ions in tetrabutylammonium tetraphenylboride are equal, it is possible to calculate single-ion conductances for systems (iii), (iv), (v), (vii), (viii), and (ix); single-ion conductances are known for bromide ion in water and in methanol. From the single-ion conductance λ, the Stokes radius $R = 0.8194 \times 10^{-8}/\lambda\eta$ is obtained; a plot of RD against D is linear, showing that R has the form $R = R_\infty + A/D$, where R_∞ is the hydrodynamic radius in a hypothetical solvent of infinite dielectric constant.

The dependence is ascribed to an electrostatic braking mechanism: As an ion

moves through a solvent, it must orient solvent dipoles in front of it and allow to relax to random orientation those behind it. Since the solvent has nonzero viscosity, a steady state will be set up in which the distribution of dipoles around the moving ion will lag behind the equilibrium distribution around a stationary ion, and hence the ion in effect carries with itself a field which opposes the external field. Correlations have been found between the constants R_∞ and A and the structure of solute and solvent.

RAYMOND M. FUOSS
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Chromatic Transients in the Photosynthesis of a Green Alga

Temporary alterations in the photosynthetic rate of red algae on alternating exposures to monochromatic red and green light (without intervening dark periods) have been previously described. These have now been found in the marine green algae, *Ulva lobata* and *Ulva taeniata*. Measurements of oxygen production were made by means of a polarized platinum electrode in direct contact with the tissue, giving a very rapid time response. In *Ulva*, on passing from a region of chlorophyll absorption (540 mμ) to one of predominant carotenoid absorption (490 mμ), a quick increase (cusp) of oxygen production occurred, followed by a depression and then by a slower recovery to a steady state equal to the previous 540 mμ level. Reillumination at 540 mμ produced a depression followed by recovery. These changes amount to some 10 or 15 percent of the total photosynthesis. Similar transients are found on passing directly from light absorbed by chlorophyll-α (688 mμ) to that mostly absorbed by chlorophyll-β (640 mμ).

It is suggested that the effect is due to enhanced respiration at 490 mμ (and 640 mμ), which starts a little after a photosynthetic increase, giving the initial cusp. This persists slightly after return to longer wavelengths (540 or 688 mμ), giving the depression, with quick recovery.

There is indication of the same effect on light-dark alternations at the same wavelengths. There are often cusps at 490 and 640 mμ, followed by enhanced respiration on darkening, while a smoother time course is found at 540 and 688 mμ, without notable respiration increase on darkening. This is in agreement with the manometric findings of Emerson and Lewis on *Chlorella*.

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Some New Theorems concerning Regular Polyhedra and Polytopes

Let any of the five regular polyhedra be projected orthogonally on an arbitrary plane P; the faces project into a network of triangles, parallelograms, or pentagons according to the case. Theorem I: *The mean square of the areas of the projected faces is independent of the choice of the plane* P, *being invariantly equal to* one-third *the* $(area)^2$ *of a face of the polyhedron.* Theorem II: *If the given regular polyhedron is an icosahedron or its dual, a dodecahedron, then also the mean* fourth power *of the areas of the projected faces is independent of the plane* P, *being equal* to one-fifth *the* $(area)^4$ *of a face of the polyhedron.*

A generalization to regular polytopes in n-dimensional Euclidean space is as follows. Let the r-dimensional faces of such a polytope be projected orthogonally on a k-flat contained in the n-space $(r \leqq k \leqq n)$. Then the mean square of the r-volume (area, if $r=2$; length, if $r=1$) of these projected faces is equal to $f(n, r, k)(F_r)^2$, where F_r denotes the r-volume of an r-face, and

$$f(n, r, k) = k!(n-r)!/n!(k-r)!$$

A special theorem, pertaining only to the 600-cell (tetrahedra) and its dual, the 120-cell (dodecahedra), both contained in four-space, is as follows: Let the 1200 two-dimensional faces (720 two-dimensional faces) of the 600-cell (120-cell) be projected orthogonally on an arbitrary plane (that is, two-flat) in the containing four-space. Then the mean fourth power of the area of these triangular (pentagonal) projections is equal to 1/15 of the $(area)^4$ of a two-face of the given polytope regardless of the choice of the plane of projection.

JESSE DOUGLAS
Yeshiva University

On the Nature of Colicine K

The colicines are antibacterial agents of unknown nature which are elaborated by many strains of colon bacilli. From irradiated cultures of the colicinogenic microorganism *Escherichia coli* K235, it is possible to obtain a mutant which does not synthesize colicine K. The O antigen of this bacillus has been obtained from the culture media in an electrophoretically homogenous state.

A comparison of the immunological properties of the colicinogenic bacillus with those of the noncolicinogenic variant has revealed that their O antigens are identical save in one respect. That of the parent has potent bactericidal properties, whereas the antigen of the variant does not. The colicinogenic bacillus elicits antibodies in experimental animals which agglutinate the homologous microorganism and precipitate its purified O antigen (termed "purified colicine K") and which neutralize the antibacterial property of the latter. The antibodies evoked by the noncolicinogenic bacillus also agglutinate the homologous and heterologous organisms and precipitate purified colicine K, but without neutralizing it. Since the O antibodies elicited by the noncolicinogenic bacillus precipitate purified colicine K in its entirety, it must be concluded that the colicine is an integral part of the O antigen of the colicinogenic bacillus.

Although the gross properties of the O antigen derived from the noncolicinogenic bacillus resemble those of the antigen obtained from the parent microorganism, a comparison of their chemical make-up has not yet been made. Such a study should reveal differences which might in turn be related to the remarkable differences in the biological properties of these two agents.

WALTHER F. GOEBEL
Rockefeller Institute
TSUNGHISA AMANO
Osaka University, Japan

Measurement of Magnetic Moments of Nuclear Excited States

Studies are at present under way in several laboratories with a view to measuring the magnetic moments of nuclear excited states. The methods of measurement generally used are subject to perturbations arising from the chemical environment of the nuclei studied.

We are engaged in a program of adapting recently refined detecting and timing techniques to study these perturbations and to obtain some results which may be considered free from these effects for states with lifetimes of the order of 10^{-9} second. The precession, in a magnetic field, of the radiation pattern observed by the angular correlation of successive radiations is determined as a function of time after formation of the excited state. Initial results with excited states of Cs^{131} and Ta^{181} appear promising and will be described. The magnetic moment of the 80-kev excited state of Cs^{131} is given by our measurements as 3.1 ± 0.2 nuclear magnetons.

This work was supported in part through AEC contract AT (30-1)-2098 by funds provided by the U.S. Atomic Energy Commission, the Office of Naval Research, and the Air Force Office of Scientific Research.

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Massachusetts Institute of Technology

Electron Microscopy of Retinal Rods in Relation to Localization of Rhodopsin

Rapid freezing preserves the visual pigments which form an integral part of all photoreceptors and should make it possible to apply the full resolving power of the electron microscope to a study of the molecular substrate of visual excitation. Thin sections of light-adapted and dark-adapted retinal rods of the frog, guinea pig, and rabbit were examined by electron microscopy; improved low-temperature fixation techniques and standard preparation procedures were used.

The techniques involve essentially rapid freezing of the fresh or glycerinated retinas with liquid helium II at −227°C, followed by substitution of the ice matrix at −130 to −80°C with alcohols, or with solutions of heavy metal salts in alcohols, and embedding in methacrylate at temperatures of −30° to −60°C by photopolymerization with ultraviolet light. Under these conditions excellent morpho-

logical and histochemical preservation of the retina is obtained without noticeable displacement of the rhodopsin or of its derivatives. The transversally arranged layered structure of the external rod segments appears very compact, and in light-adapted retinas the constituent unit disks display an intermediate dense line 15 to 20 A thick, which had not been detected previously between the double layers. In dark-adapted retinal rods an electron dense component is found, associated with the double layers, which stains selectively with heavy metal salts, particularly platinum chloride. This material disintegrates under the electron beam while being observed in the microscope when the specimen holder is cooled to −120°C. Correlation of these findings with the available evidence on the localization of the visual pigment, rhodopsin, will be discussed.

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HUMBERTO FERNÁNDEZ-MORAN
Massachusetts General Hospital and
Massachusetts Institute of Technology

Geochemical Method for Dating Obsidian Artifacts

A new dating technique, which depends upon the diffusion of water from the atmosphere into freshly worked obsidian artifacts, is evaluated and considered useful in the range 100 years well into the Pleistocene. Age is related to the thickness of the hydrated layer, as measured with the petrographic microscope. The diffusion front is sharp, and layers as thin as 0.5 to ~ 30μ have been measured. The thickness of the hydrated layer seems to follow the diffusion law $x = k\sqrt{t}$, where x = thickness of the hydrated layer, t = time, and k is a constant which is dependent on the temperature of hydration and the composition of the glass but seems relatively independent of humidity of the environment.

Obsidian artifacts from localities of supposed known age as determined by C^{14} dating, archeological estimates, and historical dating in North, Central, and South America and in Asia Minor have been examined. Rate-of-hydration curves have been tentatively constructed for different temperature environments. Owing to uncertainties in the true ages of many of the artifacts, the following rates, k^2, are still tentative: northern Alaska, 0.37 ± 0.17 μ^2 per 1000 years; southern Alaska, 0.9 ± 0.3 μ^2 per 1000 years; the United States and the Central Mexican Plateau, 4.5 ± 0.7 μ^2 per 1000 years; Iraq, 7 ± 2 μ^2 per 1000 years; and coastal tropical America, 8.8 ± 2 μ^2 per 1000 years.

Several Egyptian artifacts made of a trachytic glass, very different in composition from the other artifacts examined, hydrated at a rate of 13 ± 3 μ^2 per 1000 years.

Although the majority of the artifacts examined fit the above hydration rates, there are some exceptions.

IRVING FRIEDMAN, ROBERT L. SMITH
U.S. Geological Survey

Experimental Tests of Symmetry Principles

The recently discovered breakdown of parity and charge conjugation invariance in weak interactions has again demonstrated the danger of assuming a priori that physical systems possess particular invariance properties. An examination of the experimental evidence for some symmetries which are usually assumed has been made. These include the so-called "absolute" conservation laws, such as conservation of charge and of baryons; the invariance under rotations, which is related to the conservation of angular momentum, and the still unknown principle which appears to imply equality of the charges of certain elementary particles.

The most sensitive test of the absolute conservation laws seems to come from lower limits on the lifetimes of states which could decay except for these conservation laws. An experimental lower limit of 10^{17} years for the lifetime of atomic electrons (E. der Mateosian and M. Goldhaber, unpublished) places an upper limit on the strength of possible charge nonconserving interactions for electrons which is less by several orders of magnitude than the strength of the "weak interactions." The experimental lower limit of 10^{22} years for the lifetime of the proton puts a still lower limit on the strength of interactions which do not conserve baryons.

It is shown that the conservation of charge and existing reactions among elementary particles do not by themselves determine the relative charges of the electron, proton, and neutron. From experiment it is known that

$$|Q_p + Q_e| < 10^{-18}|Q_e|$$

and

$$|Q_n| < 10^{-18}|Q_e|$$

This may indicate the existence of some further principle which determines the charges of all elementary particles.

This work was done under the auspices of the U.S. Atomic Energy Commission.

M. GOLDHABER, G. FEINBERG
Brookhaven National Laboratory

Prevention of Mammary Cancer by Endocrinologic Methods

The oral administration of optimal amounts of certain aromatic polycyclic hydrocarbons to young, adult, female Sprague-Dawley rats resulted in the rapid, selective, and invariable production of mammary cancer. The earliest cancer was detected at 22 days, and every rat had multiple mammary cancers within 60 days. This technique for the rapid induction of mammary cancer facilitates the study of the conditions involved in the formation of breast cancer; hormones are critically involved.

Progesterone and related gestational steroids accelerated the onset and growth of mammary cancer incited by the carcinogenic phenanthrene derivatives. Large amounts of estradiol-17β block the carcinogenesis. Small amounts of this steroid have a permissive effect in carcinogenesis but, remarkably, block the vast stimulatory effects of progesterone. There are two highly effective methods of preventing mammary cancer. Hypophysectomized rats developed no cancer in 8 months. Likewise, a very effective method of preventing mammary cancer in rats treated with carcinogens is the simultaneous administration of large amounts of equine gonadotrophin, which evoke intense ovarian activity.

The development of mammary cancer with oral carcinogens is conditioned by limiting amounts of hormones, and it would appear that there are common binding sites for carcinogens and steroids in the mammary epithelium.

CHARLES HUGGINS
GIULIANO BRIZIARELLI
Ben May Laboratory for Cancer Research, University of Chicago

On a Symmetry in Weak Interactions

It appears that all the decays of the elementary particles can be explained by the universal V-A (V, vector; A, axial vector) interaction. The V-A four-fermion interaction can be derived from chirality invariance [E. C. G. Sudarshan and R. E. Marshak, *Proc. Padua-Venice Conf. Sept. 1957; Phys. Rev.* **109**, 1860 (1958)], two-spinor theory [R. P. Feynman and M. Gell-Mann, *Phys. Rev.* **109**, 193 (1958)], or mass reversal invariance [J. J. Sakurai, *Nuovo Cimento*, **7**, 649 (1958)]. However, the decision as to the fermions which enter into the fundamental interaction is made on purely phenomenological grounds (that is, to allow the observed decays and to forbid the unobserved decays). Arguments are given for regarding the baryon triplet (λ hyperon, neutron, proton) as the analog of the lepton triplet (muon, electron, neutrino) insofar as weak interactions are concerned. It is shown that the symmetry principle

$$\lambda \rightleftarrows \mu,\ n \rightleftarrows e,\ p \rightleftarrows \nu$$

leads to no contradiction with the present experimental data and makes some new predictions which can be tested experimentally. It is also possible to introduce the notion of "weak" strangeness for the leptons (which reduces to "strong" strangeness for the baryons) and to derive a unified relation between the charge, the third component of the isotopic spin, the strangeness, and the baryon (or lepton) charge. The role of an intermediate-charged, heavy-vector boson will be discussed within this framework.

R. E. MARSHAK, A. GAMBA, S. OKUBO
University of Rochester

Effect of Spreading Technique and Purity of Sample on Retardation of Evaporation by Monolayers

It was suggested by Archer and La Mer [*J. Phys. Chem.* **59**, 200 (1955)] that the retardation of evaporation of water achieved by spreading monolayers on the surface is extremely sensitive to contamination, from the air, from impurities in

the aqueous subphase, and from retained molecules of the spreading solvent. To avoid such contamination they devised a special spreading technique (using concentrated spreading solutions and high initial surface pressures); this, however, gave crystals of the compound forming the monolayer on the surface. Their method was therefore limited to one-component monolayers. Since our objective was to study mixed monolayers, we have reinvestigated the technique of spreading the monolayer by the conventional method of using dilute spreading solutions and zero initial surface pressures. By adopting stringent precautions against contamination we have now obtained satisfactory results with the conventional spreading technique and have shown that under the conditions of our investigations the evaporation resistance of a monolayer is independent of the spreading technique used. This shows, incidentally, that results obtained with the Archer-La Mer technique are reliable for one-component monolayers.

We have investigated a number of stearic acid samples from different sources. It is clear that impurities in some of these samples produce marked diminution of the resistance to evaporation by the monolayer, particularly at low surface pressures. It appears that the evaporation resistance of a monolayer is much more sensitive to impurities in the sample than are most of the physical and chemical tests that are normally used as criteria of purity.

VICTOR K. LA MER
GEOFFREY T. BARNES
Columbia University

Sugar Nucleotides in the Interconversion of Carbohydrates in Plants

Experiments with plant extracts from mung beans and other plants have demonstrated the presence of enzymes (pyrophosphorylases) capable of catalyzing the reversible formation of a number of sugar nucleotides according to the general reaction:

Uridine triphosphate (UTP) + sugar 1-phosphate
Uridine diphosphate (UDP) sugar + pyrophosphate

UDP-D-glucose, UDP-D-galactose, UDP-D-xylose, UDP-L-arabinose, UDP-D-glucuronic acid, UDP-D-galacturonic acid, and UDP-acteylglucosamine were thus enzymatically synthesized by this reaction. With the exception of UPD-D-galacturonic acid, the nucleotides were shown to be present in mung beans.

The following other enzymatic systems have been shown to exist in plants: (i) kinases capable of phosphorylating D-glucuronic acid, D-galactose, and L-arabinose, forming the corresponding sugar *l*-phosphates; (ii) a UDP-D-glucose dehydrogenase which oxidizes UDP-D-glucose to UDP-D-glucuronic acid; (iii) a decarboxylase capable of decarboxylating UDP-D-glucuronic acid to UDP-pentose; (iv) 4-epimerases that catalyze the interconversion of UDP-D-xylose and UDP-L-arabinose, UDP-D-glucose and UDP-D-galactose, and UDP-D-glucuronic acid and UDP-D-galacturonic acid; (v) transglycosylases that catalyze the formation of sucrose, callose (β-1,3-linked glucan), and a number of naturally occurring glycosides from UDP-D-glucose; and (vi) a transxylosylase which transfers xylosyl residues from UDP-D-xylose to xylo-oligosaccharides.

Thus it has been found that the sugar nucleotides are key intermediates in the pathways that lead to the formation of oligosaccharides, glycosides, and plant cell-wall constituents.

W. Z. HASSID, D. S. FEINGOLD, E. F. NEUFELD
University of California, Berkeley

Kitt Peak National Observatory—Past and Present

In January 1954, at the request of the Advisory Panel for Astronomy to the National Science Foundation, a committee was formed to explore the idea of establishing an interuniversity astronomical observatory as a way of stimulating the study of astronomy in the United States.

After several years' study, the committee offered the following recommendations to the National Science Foundation. (i) Funds should be provided for a thorough survey of possible sites for a proposed national astronomical observatory. (ii) Approximately $3.6 million should be provided for the construction of 80-in. and 36-in. stellar telescopes, and associated facilities, which would form the nucleus of the observatory. (iii) Approximately $5 million should be provided in fiscal year 1959 for an addition to the observatory of the world's largest solar telescope.

These recommendations were followed, and a nonprofit organization, the Association of Universities for Research in Astronomy, was incorporated by seven member institutions in October 1957, to administer and operate the national observatory as contractor to the National Science Foundation.

A survey of more than 120 possible sites in the United States and its possessions resulted in the final selection of Kitt Peak, 42 miles southwest of Tucson, Arizona.

A completed 36-in. telescope is expected to be operating from Kitt Peak by the end of the summer of 1959. Drawings for an 84-in. telescope have been finished. Designs for the 60-in. solar telescope are well along. Construction should start before 1961. Offices, research space, and the principal shops—optical, instrument, and electronic—are being built in Tucson.

ROBERT R. MCMATH
McMath-Hulbert Observatory, University of Michigan

Reproductive Cycles in an Equatorial Sparrow

Investigation of a free-living population of the Andean sparrow, *Zonotrichia capensis*, was directed for a period of 1 year, in Colombia, South America, toward determining the number and duration of reproductive cycles at equatorial latitudes where seasonal photoperiodism is not an influencing factor. The species may nest in all months of the year, but it was found that each individual adult male has a testis cycle of approximately 6 months' duration, in which full reproductive capacity is usually sustained for 4 months and the pituitary-gonad mechanism is involved in full rest and reconstruction for 2 months. Two complete cycles are thus carried out in a year and are a reflection of an innate rhythmic tendency uncoerced by photoperiodism and only slightly influenced by seasonal rainfall.

Information was obtained by color-banding individuals, observing them daily, and recapturing them periodically to permit laparotomy and inspection of the internally situated gonads. This surgical technique and one involving examination of the skull for age determination did not disrupt normal nesting and breeding behavior. Males are actually engaged in mating and nesting only for limited periods in the course of the time that they are physiologically capable of reproduction. Some of the young birds attain breeding condition as early as 5 months of age, but in some it is delayed to as late as 11 months.

ALDEN H. MILLER
University of California, Berkeley

Evidence of the Genetic Basis for X-ray–Induced Life-Shortening

While there is evidence that acute radiation-induced mortality in higher forms is due to the production of chromosomal damage, a genetic basis for radiation-induced shortening of the life span has not yet been demonstrated. *Drosophila melanogaster* seems well suited as a test subject for an attack on this problem. Not only can appropriate stocks be readily obtained but exposure of preimaginal stages that would soon be followed, normally, by a period of intensive cell proliferation, growth, and differentiation results in a relatively early onset of damage, whereas in vertebrates damage would be long delayed. Thus, death resulting shortly before or after eclosion, 4 to 5 days following irradiation of larvae, probably represents a shortening of life comparable in principle to that observed in mammals.

The finding that more male than female larvae are killed by x-rays (Oster and Cicak, 1958) suggested that this mortality is genetically based, since breakage followed by loss of its one X chromosome would kill a male cell, whereas a female cell would be protected by its other X chromosome. Subsequent experiments showed that, as expected, survival to adulthood following a given dose was much higher for males with a normally structured "rod" X chromosome (174/550) than for males with a ring X chromosome (103/650); it was hardly higher for females with two normal X's (215/350) than for females with one rod and one ring X (210/350), but higher than for females with attached X's (63/150). Although chromosome breakage could kill

somatic cells by either bridge-formation or hypoploidy, these results clearly implicate chromosome loss by breakage as the chief cause of this radiation induced "ageing."

This work was supported by a grant to H. J. Muller and associates from the U.S. Atomic Energy Commission [contract No. AT(11-1)-195].

IRWIN I. OSTER
Institute for Cancer Research

Movement of Heat, Chloride, and Water in Salt-Marsh Peat

The annual cycle of temperature at depth in a salt marsh has been measured to determine whether water moves through the peat fast enough to disturb the temperature relations to be expected if the water is stagnant. The measurements indicate, as a first approximation, that the temperature cycle is undisturbed, but suggest that there is a slow movement of water downward through the peat layer.

At the point of observation the interstitial water in the lower layers of peat contains almost no chloride; this indicates that the ground water in the substratum, at 15 ft depth, is fresh and that the water within the peat mass is a mixture of ground water and salt water derived from the surface. The distribution of chloride with depth may be accounted for on the assumption that there is an upward advection of ground water accompanied by a mixing process carrying salt water downward.

The two lines of inquiry thus give conflicting results concerning the movement of water. Observations by more direct methods, such as the use of tracers, are needed to resolve this difficulty, and particularly to examine the horizontal circulation. In any case the movement of water is so slow that the temperature cycle is not greatly disturbed.

It is suggested that the peat mass preserves a short-term record of recent temperatures which may be of value in climatological studies, and on the other hand that the movement of water must be considered in examining the chemistry of ancient peat deposits.

ALFRED C. REDFIELD
Woods Hole, Massachusetts

Low-Velocity Zone in the Upper Mantle of the Earth

Amplitudes of seismic body waves from explosions and the dispersion of long surface waves from earthquakes require the assumption of the existence of Gutenberg's low-velocity zone in the upper mantle.

Data are presented to indicate that this zone is present under continents and oceans at a depth of about 150 km. The low-velocity zone could account for the long-period nature of S waves and may be the source of the primary basaltic magma.

FRANK PRESS
California Institute of Technology

Role for Coenzyme A in Oxidative Phosphorylation

The uptake of inorganic phosphate by respiring submitochondrial particles was found to be enhanced by a factor liberated in soluble form when mitochondria are ultrasonically oscillated for 15 seconds in distilled water. The factor can be replaced by coenzyme A but not by a wide variety of other thiol compounds. Coenzyme A enhances the conversion of inorganic phosphate to adenosine phosphates but has no influence on the respiration which yields energy for this synthesis. It also enhances the exchange of inorganic phosphate with adenosinetriphosphate.

With intact mitochondria, depletion of coenzymes by treatment with phosphate buffer for 10 minutes at 37°C depresses—and coenzyme A partially restores—adenosinetriphosphatase activity. A role for coenzyme A in oxidative phosphorylation will be discussed.

HENRY A. LARDY
University of Wisconsin

Genetic Studies on Enzymes in Maize Endosperm

The technique of starch gel electrophoresis is being employed in a study of the enzymes involved in starch synthesis and degradation. The experiments are designed to compare enzymatic differences produced by a series of mutants which affect starch synthesis in maize endosperm. Since starch is the substrate upon which these enzymes act, their rate of migration in the gel is dependent not only on charge and size but also on their affinity for the substrate. By staining the gel with iodine it is possible to detect the enzymes that are active on the starch. They appear as red bands on the blue background. These bands show the slowest migration rate in the gel, as determined by protein staining, and are thus separated from the other soluble proteins in the extract. One of these bands has been tentatively identified as beta-amylase. It increases the opacity of the gel, and its migration can be followed during the electrophoretic separation.

Preliminary studies with the sugary mutant have revealed some differences in banding pattern which could be due to alterations in either charge or substrate affinity. All of the known mutants which affect starch synthesis in the endosperm are being tested. Those enzymes that show different banding patterns in the mutants are to be isolated and analyzed in an attempt to pinpoint the alterations caused by the mutant gene.

DREW SCHWARTZ
Oak Ridge National Laboratory

Large Molecules in Carbon Vapor

The molecular orbital theory is used in appropriate semiempirical forms to predict the properties of carbon vapor. The results indicate that linear polyatomic molecules $:C{=}C{=}C{-}\!-\!-\!-C{=}C:$ are the important species. Experimental results from the literature for C_3 are combined with the calculated conjugation or resonance energies and with the heats of formation of allene and ethylene to predict heats of formation for all larger carbon molecules. It is found that the odd species have closed shell structures and lower energies than the even species but that the even species should show greater electron affinity. Both of these results are consistent with the mass spectrometric results of Honig and of Chupka and Inghram. Molecular spectroscopic data on C_3O_2 are used to estimate the free energy function increments for the species above C_3.

The calculated partial vapor pressures predict C_5 to be the most abundant species in the saturated vapor even at 2000°K, with C_7 becoming comparably abundant in the 2500 to 3000°K range. At higher temperatures even larger molecules should become important. The results are shown to be generally consistent with all reliable vaporization data, provided the evaporation coefficients decrease rapidly for increasing molecular size and vary for different crystal surfaces of graphite.

The calculated electronic energy levels for C_2 and C_3 agree satisfactorily with the observed spectra, and trends are predicted for both even and odd larger species. It is proposed that liquid carbon consists of essentially infinite linear chains of this type. Considerations of both entropy and energy lead to the prediction of heats of fusion of about 10 kcal/g atom at 4000°K; the agreement between the two values indicates at least the absence of any serious inconsistency.

KENNETH S. PITZER
ENRICO CLEMENTI
University of California, Berkeley

Relation between Reproductive Capacity of Polio Viruses at Different Temperatures in Tissue Culture and Neurovirulence

It was recently reported [A. Lwoff and M. Lwoff, *Compt. rend.* 248, 154 (1959)] that temperatures of 39° to 41°C affected only slightly the reproduction in KB cells of the highly virulent Mahoney strain of type 1 polio virus but greatly inhibited attenuated strains, the extent of inhibition being related to the degree of attenuation. While a variety of other in vitro characters have previously been correlated with neurovirulence for monkeys, studies on reverse mutants failed to establish any one of them as an important determinant of the complex property of neurovirulence. The present studies, however, showed that the genetic factors which influence the reproductive capacity of polio virus at higher temperatures are very closely correlated with neurovirulence. Thus, mutants of the moderately attenuated "Brun-End-Chimp" strain and of the highly attenuated "L Sc, 2 ab" strain, which were selected by stepwise cultivation in KB cells at increasingly higher temperatures until they reproduced well at 41°C, proved to be fully virulent on intracere-

bral inoculation of as little as 1.7×10^1 PFU in monkeys, while repeated passages of these strains in KB cells at 37°C yielded virus that was not paralytogenic in doses of 10^8 PFU. On the other hand, while minimal doses of the original "Brun-End-Chimp" virus were paralytogenic when placed directly in the gray matter of the lumbar spinal cord of monkeys, a mutant selected for its capacity to reproduce at 25°C was not paralytogenic in doses of 10^6 PFU; this confirms an observation on other strains of polio virus originally reported by Dubes and Wenner [*Virology* 4, 275 (1957)].

Titration of polio viruses in monkey kidney monolayer cultures incubated at 36° and 40°C has proved helpful in differentiating highly virulent from attenuated strains, but not in distinguishing quantitative differences in neurovirulence as determined by tests in monkeys. Highly attenuated type 1 and type 2 strains exhibited little or no change in their limited capacity to reproduce at 40°C in tissue culture after multiplication for many weeks in the intestinal tract of children, even when a febrile illness (38°–40°C) intervened. Partial modification in the reproductive capacity at 40°C of excreted type 3 virus was not correlated with neurovirulence for monkeys.

ALBERT B. SABIN
University of Cincinnati College of Medicine
ANDRE LWOFF
Institut Pasteur

Extreme Sensitivity of an Immature Stage of the Mouse Ovary to Sterilization by Irradiation

Comparisons of the fertility of female mice irradiated at various stages from the embryo to the adult revealed that, during the first 2 weeks after birth, the ovary shows a remarkable change, from less sensitivity than is found in the adult to much greater sensitivity.

Females receiving 300 r of x-irradiation (80 to 90 r/min) on the day of birth, when most oocytes are apparently in pachytene stage, commonly produced nine or ten litters, whereas adult females given the same acute dose never produced more than two litters (mean: 1.4).

In contrast to this marked resistance of the ovary of the newborn, the ovary during the second week after birth shows an extreme sensitivity, even to low-intensity irradiation. A total dose of 85 r of continuous Cs^{137} gamma irradiation given during this week (dose rate only 0.0084 r/min) caused sterility after production of either a single litter or a second litter of reduced size. Sensitivity to low-intensity irradiation rapidly diminishes after this stage. Adult females given approximately the same total dose at the same dose rate produced an average of 13.3 litters and 86 progeny per female (numbers which are not significantly different from those for controls).

The much greater sensitivity during the second week after birth coincides with the time when oocytes have recently reached dictyate stage. It is quite possible that the comparable stage of development of the human ovary, which is apparently attained before birth, has a similar extreme sensitivity to radiation.

W. L. RUSSELL,
LIANE BRAUCH RUSSELL,
M. H. STEELE, E. L. PHIPPS
Oak Ridge National Laboratory

Light, Growth, and Reproduction of Poria ambigua

Poria ambigua does not form hymenium and basidiospores on a basal agar medium containing dextrose, mineral salts, B vitamins, purine and pyrimidine bases, and casein hydrolyzate unless exposed to light. The blue end of the visible spectrum is effective, the red end is not. Short exposures to faint light are adequate. The effect of light extends into mycelium, which grows in the dark after illumination. This suggests the production of a substance in the light which moves into mycelium formed later in the dark and induces reproduction. The addition of natural substances such as tomato juice, yeast extract, or malt extract to the basal medium increases growth and interferes with reproduction. Local inhibition of growth on such media by actidione permits hymenium to form. Different isolations of the fungus vary in their reproductive potency. Light also affects the rate of growth of the fungus, decreasing it on some media and increasing it on others.

It is proposed that three unidentified growth substances may be concerned: *x* is formed in the light and is required for the series of physiological and morphological changes which result in reproduction. The ability of the fungus to synthesize *y* limits growth on the basal medium and is found in natural substances. Substance *z* limits growth in the dark in the presence of luxus amounts of *y*. The synthesis of *z* is favored by light, with the result that growth in the presence of adequate amounts of *y* is greater in the light than in the dark.

WILLIAM J. ROBBINS
Bronxville, New York
ANNETTE HERVEY
New York Botanical Garden

Biogeochemical Concentration of Deuterium in the Marine Environment

During studies of the calcium carbonate deposits of the Bahama Banks, conducted by the U.S. Geological Survey in 1955 and 1956, a hydrogen-gas–producing marine bacterium, occurring in high concentration within the superficial sedimentary layer, was isolated. Mass spectrometric analyses of the gas generated by this microorganism revealed an unexpectedly high percentage of light hydrogen (protium) and an apparent absence of the normal isotope, deuterium, in the gas mixture.

Subsequent analyses of the sea water dextrose substrate used to culture this marine bacterium showed the normal distribution of the protium-deuterium isotopes. It was apparent that the deuterium in the medium was being selectively fractionated by the cellular biochemical processes.

Since publication of these initial findings [*Science* **127**, 1394 (1958)], interest aroused as a result of this chance discovery has prompted a renewal of that phase of the Bahama Banks study connected with the equilibrium

$$H_2O + HD \rightleftharpoons H_2 + HDO$$

Particular attention has been focused on the precise biochemical mechanism which may be responsible for the initial separation of protium and deuterium. This is not only a matter of academic interest; a more thorough understanding of the biochemical processes involved in separation and concentration of deuterium may have economic and public health implications. Such understanding could facilitate the production of heavy water and lead to reduction in the cost of producing it, and it could give a clearer insight into the biochemical processes associated with aging and abnormal tissue development.

Of academic import is the possible significance of the role of marine bacteria in the concentration of heavy water in the seas during past geologic time. Today, sea water contains from 10 to 25 percent more D_2O than fresh water, the atmosphere, ice, and igneous rock.

Marine bacteria are undoubtedly important agents in the separation and accumulation of many other rare elements besides deuterium in the marine environment.

F. D. SISLER
U.S. Geological Survey

Elimination of Deoxyribonucleic Acid from Soma Cells

Current wide-spread interest in the role of deoxyribonucleic acid (DNA) in protein synthesis brings into the foreground an old enigma of cytology—the elimination of parts of, or of whole, chromosomes from the soma cells of an embryo so that the somatic chromosome complex may be quite different from that of the germ cells.

Evidence will be reviewed indicating that the excess DNA of germ cells plays an essential role in the building up, in the cytoplasm of the oocyte, of great reserves of proteins and nucleic acids required for the development of embryos to the stage when they can obtain food from the environment. The elimination of the excess DNA from soma cells is highly advantageous to the organism because it frees soma cells, or nuclei, from the necessity of synthesizing anew, or reassembling nucleotides not required for somatic cell development, thus conserving the supply of nucleic acid precursors previously stored in the cytoplasm of the oocyte. In this way the more rapid development of the embryo is possible.

THEOPHILUS S. PAINTER
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Ionic Centrifuge and Fusion Nuclear Power

The ionic centrifuge [J. Slepian, *Phys. Rev.* **112**, 1441 (1958); *Nuclear Sci. and Eng.* **3**, 108 (1958)] proved unsatisfactorily for the separation of isotopes because of the high energy of random motion or high temperature received by the ions and electrons traversing the induced currents in the gas. This action is reversible, however, and the temperature may be again lowered by making the ions and electrons traverse currents opposite in direction to those to which they had been originally subjected.

The procedure is as follows: Connect the cylinder of the centrifuge directly to the short arc. Energize the end plates positively, but not too highly positively. They then draw only a space-charge-limited electron current. The main central discharge going from arc to cylinder bears only a radial electric field, which rises to a high positive potential and falls again to zero potential on coming to the cylinder. Electrons from the central discharge crowd up and down into its boundaries, their freed electric field lying up and down parallel to the magnetic field; then, beyond the voltage maximum, they draw back into the central discharge again. This motion out and in of the electrons from the positive ions constitutes radial and axial current densities in the gas. In addition, there will be circumferential current densities which change sign on passing the voltage maximum. The temperature of the ions and electrons rises on traversing the circumferential currents prior to the voltage maximum and then falls again to zero on traversing the reversed circumferential currents from voltage maximum to the cylinder.

Thus, we have here high-temperature ions and electrons out in space, with only low-temperature ions caught by the electrodes. The application of this to the generation of fusion nuclear electric power is obvious.

JOSEPH SLEPIAN
Pittsburgh, Pennsylvania

Maximum Growth Rates in Synchronized Cultures of Green Algae

The minimum generation time, or doubling time, for the low-temperature strains of *Chlorella* has long been known to be near 8 hours. The minimum generation time for the recently introduced high-temperature strains of *Chlorella* has been reported to be 2.5 hours in steady-state suspensions. By culturing high-temperature algae in synchronized suspensions, the doubling time was reduced to 1.8 hours and, with the further refining of the technique, to 1.5 hours. Calculated on a 24-hour basis, the increase in dry weight for the low-temperature algae in steady-state culture is eightfold; for the high-temperature strains the increase is 1000-fold. In synchronized cultures of the high-temperature strains, the increase is 64-fold in 9 hours. If this multiplication rate could be sustained for 24 hours, the dry weight of the algal cells would increase by a factor of 65,000.

The difference in the rates of reproduction between synchronized and steady-state cultures may be due to the suspected detrimental effects of strong light on cell division and, consequently, on the over-all process of growth. The adverse effect of light is eliminated in synchronized culture, since no visible cell division takes place during 9 hours. Another possible explanation is the absence of older cells from the synchronized cultures. Algal cells approaching the end of the life cycle have a reduced metabolic activity and, therefore, can be expected to have a lower growth rate.

CONSTANTINE SOROKIN
ROBERT W. KRAUSS
University of Maryland

On the Possibility of Avoiding Infinities in Quantum Field Theory If Space-Time Is Curved

We consider the second quantization for bosons of the theory for a single particle. With (isotopic) spin this will cover such fermion-boson theories as can be expressed in terms of bosons only by the apparatus of the neutrino theory of light. The corresponding nonquantum theory in curved space-time can be reduced to canonical form and then can be quantized in the usual way. We here consider the simplest case of a particle without spin in curved space-time with but one space-dimension, invariant for observers with various velocities at each point-event.

If we express the first quantized theory in terms of the rapidity u, the momentum and energy operators for a free particle are $X_0 = mc \sinh (u/c)$ and $H_0 = mc^2 \cosh (u/c)$. A relativistically invariant interaction is introduced by taking further momentum and energy

$$X_1 = (X_0, J), \; H_1 = (H_0, J)$$

where J is a matrix of the form

$$(u_1|J|u_2) = J(u_2 - u_1).$$

If J falls off sufficiently rapidly as $(u_2 - u_1)$ increases, it provides an invariant "cut-off," and powers of the operators are finite, but $(X, H \neq 0$, and space-time is curved. If J is a constant, which corresponds to the usual type of field interaction, powers of the operators are not finite. Further, the limit of space-time curvature as this last form is approached is not zero, but rather a δ-function of effective distance from a particle.

L. H. THOMAS
Watson Scientific Computing Laboratory

Restoration of Antibody-Forming Capacity in X-rayed Rabbits

As compared to controls, rabbits that received 400 r of total-body x-irradiation 24 hours before receiving injections of 1.6×10^9 red cells of sheep showed on the average a 2.7-fold lengthening of the induction period, a 36-percent lower rate of rise in antibodies, and an 88-percent lower geometric peak titer.

Earlier we found [*J. Infectious Diseases* **98**, 75 (1956)] that antigen mixed with minces or extracts of rabbit or mouse spleen (but not of rabbit kidney or muscle) partially restored the rate of rise and peak titer. Preparations of yeast and HeLa cells were completely restorative. Recently ribonucleic acid and deoxyribonucleic acid enzymatically degraded by their specific nucleases were found to be partially restorative, but the nucleic acids and pure nucleosides and nucleotides were inactive. Among chemically defined substances, kinetin partially restored and colchicine completely restored the rate of rise and peak titer. Little if any antibody is synthesized during the induction period, and no restorative substance affected the x-ray lengthening of this period. Restoration is probably related to the early radiosensitive period of the immune process which determines the amount of antibody formed and eventually involves some aspect of the nucleic acid control of protein synthesis.

WILLIAM H. TALIAFERRO
University of Chicago
BERNARD N. JAROSLOW
Argonne National Laboratory

Cellular Differentiation through Asymmetrical Mitosis and Mitotic Induction in the Developing Epidermis of the Grass Leaf

In leaves of grasses, exemplified by barley, orchard grass, maize, and sorghum, stomata occur in vertical rows on either side of each vascular bundle. Each stomatal complex includes two guard cells flanked by two subsidiary cells; these alternate regularly with undifferentiated epidermal cells. Differentiation proceeds in the intercalary meristem at the base of each leaf and can be studied from strips of leaves fixed in Carnoy's fixing fluid and stained in acetocarmine or Fuelgen stain. Differentiation of the stomatal rows is evident through more frequent mitoses, which give rise to cells smaller than those in adjacent rows. The final series of mitoses is asymmetrical. Immediately after telophase, the distal nucleus becomes small and strongly staining and the proximal nucleus becomes larger and more weakly staining. Shortly thereafter, cells in adjacent rows divide, their mitotic spindles being consistently oriented with one pole adjacent to the smaller cells in the stomatal row.

Evidence is presented indicating that the latter cells induce both this orientation and the mitoses themselves. At telophase, these give rise to a small cell with a heavily staining nucleus adjacent to the stomatal row and a large nucleus in the middle of the original cell. These small cells become the subsidiary cells of the stomatal complex. Immediately after their formation, the smaller cells in the stomatal row divide transversely and eventually become the guard cells. Differentiation can be altered by applying mercapto-

ethanol, isopropyl-phenyl carbamate, and other chemical agents.

The significance of this system as a tool for studies of morphogenesis and developmental genetics is discussed. This research was conducted with the aid of National Science Foundation grant No. G-3737.

G. LEDYARD STEBBINS
University of California, Davis

Further Electron Micrographic Observations on Indanthrene Dyes

In a previous communication we showed that under the electron microscope crystals of a number of indanthrene dyes exhibit molecular striations like those first observed with metallic phthalocyanins. We have been continuing these observations to provide the experimental basis for understanding them. Striae can be seen in crystals viewed close to and far from focus; accordingly, it was at first thought that they were insensitive to focus. This has proved not to be the case.

In the present communication it is shown how the complex pattern of striae furnished by the dye indanthrene scarlet R varies as a function of objective lens current of the viewing microscope. Similar though less complicated changes have been observed for copper phthalocyanin and for indanthrene olive TWP.

A number of other observations important for interpreting these phenomena, such as their dependence on crystal thickness, have been made. The basic spacings observed with scarlet R, like those of the phthalocyanins, can be identified with important x-ray diffraction lines. Fine structure in the interference pattern produced by this dye depends on focus; it is related to, but need not equal, the basic spacings.

R. W. G. WYCKOFF
L. W. LABAW
National Institutes of Health

Evidence by Isotope Tracers of Perpetual Replacement of Mature Nerve Fibers from Their Cell Bodies

According to earlier findings (Weiss, 1944; Weiss and Hiscoe, 1948), the axon of a nerve fiber grows forth perpetually from the nucleated cell body at about 1 mm per day, furnishing a steady supply stream to replenish peripheral macromolecular systems, including proteins, lost by metabolic degradation. Attempts to demonstrate this "axonal flow" by radioactive phosphorus (Shepherd, 1951; Samuels, Boyarski, Libet, and Brust, 1951; Ochs and Burger, 1958) have been suggestive but not conclusive. More positive preliminary tests with C^{14}-lysine (Waelsch, 1958) have led to the present crucial tests.

These were carried out in large Mexican axolotls whose lateral line nerves (length > 200 mm) contain the same ($\pm$) 40 nerve fibers from center to periphery. Each animal received a single intraperitoneal injection of a mixture of C^{14}-labeled lysine, leucine, isoleucine, valine, and phenylalanine (the injections were given with the collaboration of Waelsch and Lajtha). After 168 and 214 days, respectively, the lateral line nerves were excised and radioautographed. Photodensitometric scanning of the autographs revealed a marked linear gradient of radioactivity from center to periphery, indicating that amino acid incorporation into nerve protein had been confined to the cell bodies, the labeled mass being conveyed peripherad at a rate which, to judge from the front end of the labeled column, is of the predicted order of 1 mm per day. The gradient is attributable to the continual feeding back of peripheral, C^{14}-labeled, split products to the central source of neuroplasm, the fronts of consecutive waves being correspondingly staggered.

The experiments seem to confirm the earlier findings that the neuron is in a state of continuous self-renewal from the local source of the nucleated cell space. If the results can be extrapolated to other cell types, protein synthesis in general would have to be localized in the nuclear territory.

PAUL WEISS
Rockefeller Institute for Medical Research

Note on the Internal Structure of the Moon

The moon has a triaxial nonequilibrium shape, as determined from its motion and its proper libration. It has been assumed that this was acquired when the moon solidified, at a lesser distance from the earth than it is now. This requires great strength in the moon's interior, and it is difficult to reconcile this with probable interior temperatures. It is possible to explain this as being due to a variation in density with angular position within the moon. Surface variations in density will not affect the ellipticities to a first approximation in small quantities. In this case great strength must exist in the outer parts but not in the deep interior. Such variation in density may be due to variation in composition, indicating a slightly heterogeneous structure with angular position. A nonuniform structure is indicated, suggesting that the moon was never melted.

The recent observations of Kozyrev also indicate that the moon's temperature is increasing rather than decreasing. Tidal effects on the moon due to the varying earth-moon distance may give rise to reported lunar surface patterns.

H. C. UREY, W. M. ELSASSER,
M. G. ROCHESTER
University of California, La Jolla

Directed Formation of the Actinomycins—Chemical Structure and Biological Activities

Actinomycin, discovered in 1940, was the first antibiotic isolated from a culture of an actinomycete; however, it was found to be too toxic for use in the treatment of infectious diseases. Later, it proved to be effective in very low concentrations against certain experimental neoplasms in animals. Various attempts have since been made to modify the chemical structure of the molecule, both by chemical means and by enzymatic degradation, in an effort to reduce its toxicity. The substances generally obtained as a result of such treatment proved to be less toxic but also less active biologically. Numerous actinomycin preparations have been isolated from different *Streptomyces* species; those examined proved to be chromopeptides, differing solely in their amino acid composition. They revealed slightly differing toxicities and somewhat different effects upon microorganisms and experimental neoplasms.

Streptomyces antibioticus synthesizes a mixture of five or six actinomycin components. The nature of the nitrogen source influences greatly the quantitative and qualitative composition of the actinomycin mixture synthesized. Sarcosine selectively affects the production of actinomycins II and III. High concentrations of exogenous L-proline reverse this effect. The addition of DL-pipecolic acid to the medium results in the synthesis of several new actinomycins. Actinomycins II and III proved to be somewhat less toxic than the previously examined actinomycins and still possessed activity against the ascitic form of the Gardner lymphosarcoma. Actinomycin II contains four residues of sarcosine but no proline, whereas actinomycin III contains three residues of sarcosine and one molecule of proline. The results obtained are compatible with the view that exogenous sarcosine and pipecolic acid compete with and replace the endogenously synthesized proline in the peptides of some of the actinomycins.

S. A. WAKSMAN, E. KATZ,
W. A. GOSS, L. H. PUGH,
M. SOLOTOROVSKY, O. AUERBACH
Institute of Microbiology, Rutgers University

A. W. JOHNSON
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Nottingham University

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While the herring seiners go looking for gourmets to eat their catch, other fishermen are setting their seines for *Brevoortia tyrannus*, the fish the Pilgrim saw the Indian drop into the hole with the corn kernels, the most abundant of Atlantic coast fishes, ignored by cookbooks, the menhaden. To get it into the field hand's lunch pail, it is converted into chicken muscle tissue.

This complex process requires cooking the menhaden at a temperature below 180°F (which will coagulate and separate the protein but not degrade it); then squeezing, drying, and grinding the stew, adding it to corn and other agricultural and mineral products, and feeding the mixture to chickens. The drying step is critical. If oxidation of the fish fat gets out of hand, not only may the protein and vitamins be destroyed, but fire may break out.

This we have set about to prevent. To assure ourselves of a good supply of photographic developer, we long ago set up to make phenolic reducing agents in large quantity. We made so much that we had to find other markets. The difference between a reducing agent and an antioxidant is a mere technicality. One of our antioxidants, butylated hydroxytoluene, has long been accepted by competent and critical authorities as safe even for direct human food, at the proper levels. As *Tenox BHT—Agricultural Grade*, we are now selling it to the fish meal people. It saves them money. Their 40-ton piles of fish scrap require less costly shifting to keep them cool. A week is reported to have been cut off the curing time.

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Later other scientists in turn covered themselves with glory by discovering that for photographic exposure this was not strictly true, and still others won Ph.D.'s by explaining why not. Intensity and duration slip the shackles of reciprocity a little. Over the broad spectrum of durations from millimicroseconds to months, a certain optimum rate of feeding energy to a silver halide emulsion is encountered. The manufacturer can roll the optimum somewhat one way or the other.

Calls for shifting it to favor the effectiveness of very dim light come from astronomers, among others. From an observatory director's viewpoint, cutting hours off exposures is like having more telescopes.

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her Kodacolor Prints. With what such machines cost, they have to work when you turn them on. Like virtue, reliability becomes its own reward. This viewpoint our electronics engineers must quickly acquire.

Another corps of Kodak electronics engineers bring to TV-systems development the experience of packaging radio transmitters and receivers to work inside artillery shells. This, too, we got into from catering to the public's photographic desires. The armed forces had figured that an outfit capable of flooding the world with accurately timed photographic shutters could do as well with artillery fuzes. Later, when fuzes came to be operated by radio echos instead of clockwork, what was more natural than that we make that kind?

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Meetings

Facies Model Conference

A discussion concerning sedimentary rocks was held at the Illinois State Geological Survey on 4–5 Nov. 1958, for the purpose of pooling the knowledge and experience of the group concerning three topics: the existence and number of sedimentary associations; the possibility of establishing a model for each association that would emphasize the areal distribution of lithologic units within it; and the exploration of the spatial and sequential relations between the associations.

The participants included Albert V. Carozzi (University of Illinois); Francis J. Pettijohn (Johns Hopkins University); P. E. Potter (Illinois State Geological Survey); John Rodgers (Yale University); W. W. Rubey (U.S. Geological Survey); Raymond Siever (Harvard University); L. L. Sloss (Northwestern University); and E. L. Winterer (University of California, Los Angeles). Under the direction of a chairman, informal discussion was substituted for formal papers.

The first action of the group was to agree that recurring patterns of sedimentation give rise to a relatively small number of fundamental sedimentary associations rather than to an indefinite number of independent and unique patterns in space and time. This concept makes possible the broad application of a relatively small number of general principles to the identification and interpretation of the majority of sedimentary deposits.

The sedimentary association was defined as a collection of commonly associated sedimentary attributes. In the multidimensional space defined by the basic sedimentary attributes, a sedimentary association is simply a clustering of points. Subsequent discussion of the various sedimentary associations repeatedly emphasized the fact that no single variable or attribute is sufficient to define one of these clusters or associations, just as no single characteristic can be used by anthropologists to define a race or by psychologists to define personality. Although gradations between associations were recognized and emphasized at the very beginning, it was decided not to consider them until the basic associations had been defined.

The factors most often mentioned in the definition of a sedimentary association were gross geometry (thickness and areal extent); continuity and shape of lithologic units; rock types (maturity of the clastics and character of carbonates), sedimentary structures, and fauna (types and abundances). Five major associations were outlined.

Before discussion of facies models was initiated, the relations between the various associations were discussed briefly but were not exhaustively explored. Discussion made it immediately apparent, however, that not all transitions between the associations are possible and that some occur much more frequently than others.

A facies model was defined as the distribution pattern or arrangement of lithologic units within any given association. In the early stages of geological exploration, the function of the model is to improve prediction of the distribution of lithologic types. Successful prediction, it was agreed, is the measure by which a geologist's understanding of a sedimentary association should be judged. Facies models were discussed under sandstone and carbonate subtypes.

Although general agreement was not reached concerning what should be included in a facies model, both basin architecture and the relationship of transport direction to depositional strike played prominent roles in the discussion. The mechanism of quartz and carbonate

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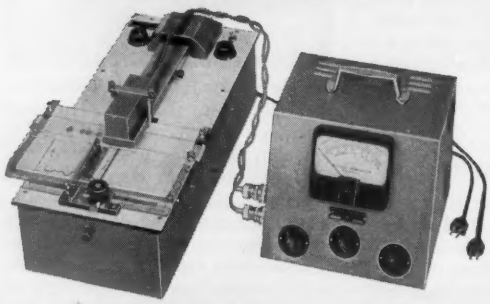

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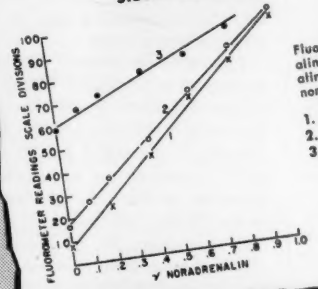
*Ref: Fluorometric Determination of Adrenalin and Noradrenalin in Aqueous Solution
SIDNEY ROSTON, Anal. Chem. Vol. 30, Pg. 1363



Fluorescence vs. amount of noradrenalin with varying amounts of adrenalin present, obtained according to noradrenalin method

1. Adrenalin, 0 γ; water reading, 6
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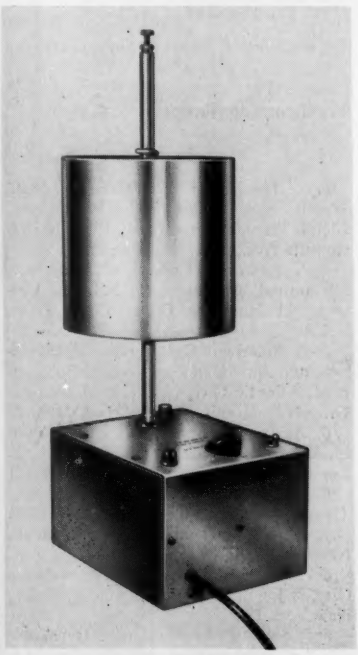

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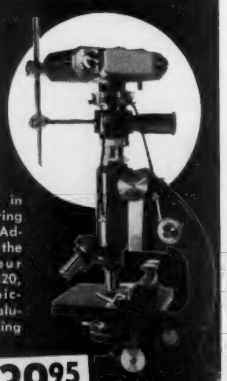

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sand dispersal, especially on shallow marine shelves, was a recurring topic of discussion. The fact that basins of markedly different size have similar distribution patterns of major lithologies was generally agreed to indicate that scale is not a critical factor. As discussion proceeded, the number of elements considered important tended to increase rather than decrease. Thus, it was suggested that the model should incorporate at least some elements of the regional tectonic setting. Although a distinction had already been made between local prediction, such as prediction of the direction of a washout in a coal mine, and regional prediction, concerned with subregions within a basin, this suggestion tended to embrace an even larger realm.

Judged in its entirety, the group discussion clearly pointed out those areas of knowledge that permit generalization, the areas in which problems are clearly recognized and stated but for which definitive answers are not available, and the areas in which the problems are not as yet clearly formulated. The sedimentary association, the mechanism of sand dispersal on a shallow marine shelf, and the facies model respectively illustrate each of these areas. Probably because discussion rather than achievement of fixed goals or conclusions was sought, the group was effective in all three areas. Meetings such as this should prove to be an effective supplement to more formal symposia and national meetings.

PAUL EDWIN POTTER
Illinois State Geological Survey, Urbana

Forthcoming Events

June

3–5. Physics of Precipitation, conf., Woods Hole, Mass. (H. Weickmann, Cloud Physics Committee, 1515 Massachusetts Ave., NW, Washington 5.

5–7. American College of Angiology, 5th annual, Atlantic City, N.J. (A. Halpern, 11 Hampton Court, Great Neck, N.Y.)

5–7. American Gastroenterological Assoc., and American Gastroscopic Soc., annual, Atlantic City, N.J. (H. M. Pollard, University Hospital, Ann Arbor, Mich.)

6. American Acad. of Tuberculosis Physicians, Atlantic City, N.J. (O. S. Levin, P.O. Box 7011, Denver 6, Colo.)

6. International Cardiovascular Soc. (North American Chapter), Atlantic City, N.J. (P. T. DeCamp, 3503 Prytania St., New Orleans, La.)

6–7. American Diabetes Assoc., Atlantic City, N.J. (E. Paul Sheridan, 1 E. 45 St., New York 17.)

6–7. Society of Investigative Dermatology, Inc., 20th annual, Atlantic City, N.J. (H. Beerman, 255 S. 17, Philadelphia 3, Pa.)

6, 20, and *27.* Recent Advances in Medical Technology, symp., Staten Island, N.Y. (N. Colosi, Wagner College, Staten Island, N.Y.)

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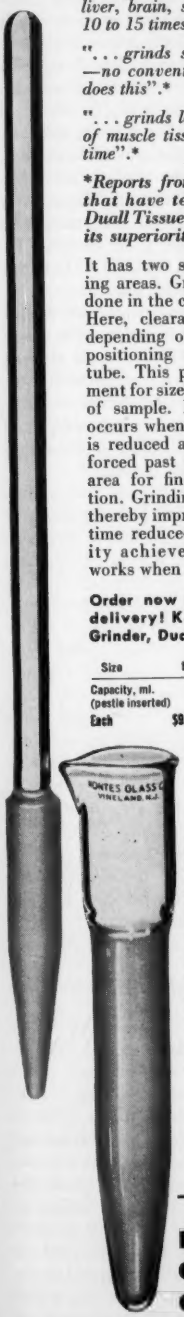

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7–11. American Soc. of Heating and Air Conditioning Engineers, semi-annual, Vancouver, B.C., Canada. (A. V. Hutchinson, ASHACE, 62 Worth St., New York 13.)

7–13. Fertility and Sterility, 3rd world cong., Amsterdam, Holland. (W. W. Williams, 20 Magnolia Terrace, Springfield, Mass.)

8–9. Isotope Effects in Chemistry and Biology, conf., Lemont, Ill. (Miss B. Litt, Isotope Effects Conference, Argonne Natl. Lab., P.O. Box 299, Lemont.)

8–12. American Medical Assoc., Atlantic City, N.J. (F. J. L. Blasingame, 535 N. Dearborn St., Chicago 10, Ill.)

8–12. Association for Research in Ophthalmology, Inc., Atlantic City, N.J. (L. V. Johnson, 10515 Carnegie Ave., Cleveland 6, Ohio.)

9–11. Canadian Federation of Biological Societies (Canadian Physiological Soc., Pharmacological Soc. of Canada, Canadian Assoc. of Anatomists, Canadian Biochemical Soc.), Toronto, Ontario, Canada. (E. H. Bensley, CFBS, Montreal General Hospital, 1650 Cedar Ave., Montreal 25, P.Q.)

9–11. Interferometry, intern. symp., Teddington, England. (Intern. Symp. on Interferometry, Natl. Physical Laboratory, Teddington.)

9–12. Health Technicians, 6th intern. cong., Paris, France. (Secrétariat Général du VI[e] Congrès-Exposition International des Techniciens de la Santé, 37, rue Montholon, Paris 9[e].)

10–12. Gas Chromatography, 2nd intern. symp., East Lansing, Mich. (H. S. Kindler, Technical and Educational Services, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.)

10–12. International Union of Crystallography, Stockholm, Sweden. (W. Parrish, Apparatus Commission, Philips Laboratories, Irvington-on-Hudson, New York.)

11–12. Undiscovered Earth, annual research conf., Birmingham, Ala. (Southern Research Inst., 2000 Ninth Ave., S. Birmingham 5.)

11–13. Society for Study of Development and Growth, symp., Madison, Wis. (W. P. Jacobs, SSDG, Dept. of Biology, Princeton Univ., Princeton, N.J.)

11–14. American Electroencephalographic Soc., Atlantic City, N.J. (J. K. Merlis, University Hospital, Baltimore 1, Md.)

11–14. Wilson Ornithological Soc., Rockland, Maine. (A. Bagg, Farm St., Dover, Mass.)

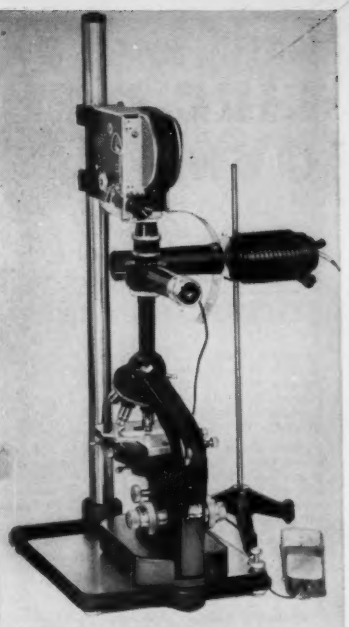
13–22. Information Processing, 1st intern. conf., Paris, France. (U.S. Committee for the Intern. Conference on Information Processing, Box 4999, Washington 8.)

14–17. American Dairy Science Assoc., Urbana, Ill. (H. F. Judkins, 32 Ridgeway Circle, White Plains, N.Y.)

14–18. American Soc. of Mechanical Engineers, semi-annual, St. Louis, Mo. (O. B. Schier, II, ASME, 29 W. 39 St., New York 18.)

14–19. Society of Automotive Engineers, summer, Atlantic City, N.J. (Meetings Div., SAE, 29 W. 39 St., New York 18.)

(See issue of 17 April for comprehensive list)



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Letters

Women Scientists

The editorial "Science for the misses" [*Science* **129**, 749 (1959)] leads me to believe that your readers will be interested in some data which I have assembled (with the help of Barbara Drew Atwood). Graduates of seven women's colleges who are included in *American Men of Science* were counted, and the numbers were expressed as percentages of total living graduates of the respective colleges. The results follow (the first percentage is for the physical sciences; the second, for the biological): Mt. Holyoke, 0.46, 0.75; Bryn Mawr, 0.48, 0.57; Goucher, 0.40, 0.53; Vassar, 0.34, 0.32; Wellesley, 0.24, 0.24; Smith, 0.14, 0.25; and Radcliffe, 0.14, 0.13. The total is 532/87,012, or 0.61 percent.

Less than 1 percent of the 87,012 alumnae who were living in 1956 are in *American Men of Science*. Is this an indication of lack of opportunity for women scientists, of less innate scientific ability in women, or of women's greater interest in home, children, and cultural activities other than scientific?

I believe that both men and women can be grouped into three categories: (i) those who must be scientists at any cost; (ii) those who are not interested and who would never be scientists; (iii) a group intermediate in size—those who, under the stimulus of economic necessity, prefer science to any other field. Most men in both categories (i) and (iii) become scientists. Women in group (i) persist in their study, but most women in group (iii) work as assistants, and so on, until marriage, children, or economic improvement releases them.

I sometimes wonder, after many years of teaching college science, if it is wise to urge or to tempt persons, men or women, in group (iii) to become scientists. To give all possible aid and encouragement to those in group (i) might, in the long run, accomplish more.

ANNA R. WHITING
University of Pennsylvania, Philadelphia

Supercooled or Subcooled?

Braham's article, "How does a raindrop grow?" [*Science* **129**, 123 (1959)], is an excellent survey of our knowledge on this subject. I would, however, like to raise a question about the use of the word *subcooled* to indicate cooling of water below 0°C. To the cloud physicist and other scientists, *subcooled* and *supercooled* are generally regarded as interchangeable. It seems, however, a little unwise and completely unnecessary for scientists to use two words, which, it would seem from their structure, ought to have opposite meanings, to indicate

the same thing. The prefix *sub* ordinarily is accepted as meaning "less than," and *super,* as meaning "more than" (for example, *subhuman* and *superhuman*). Inasmuch as the word being modified by the prefix is *cooled* and not *temperature,* it appears that the word *supercooled* is preferable to *subcooled* for indicating excessive cooling.

In reaching this conclusion I examined two standard sources [*Webster's New Collegiate Dictionary* (Merriam-Webster, 1958) and the *U.S. Weather Bureau Weather Glossary* (1945)]. Both listed *supercooled* ("to cool below the freezing point without solidification"); neither listed *subcooled.*

In view of the above considerations and in view of the fact that so many scientific articles are now read by nonscientists and by foreign scientists, I would like to suggest that serious consideration be given to avoiding the ambiguity that might arise from use of the word *subcooled* (and, similarly, *undercooled*) in scientific writing.

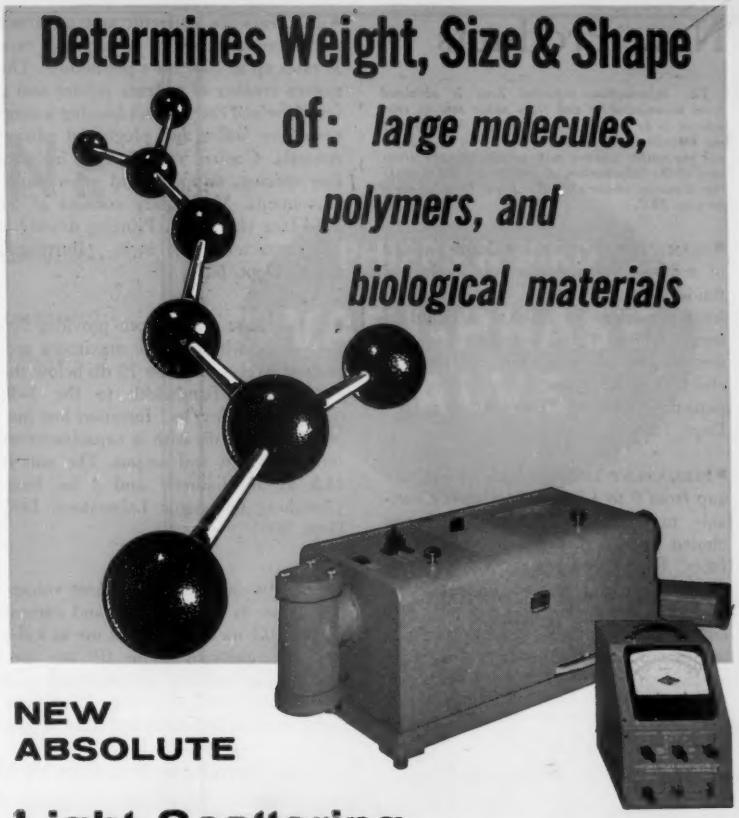
HERBERT S. APPLEMAN
Air Weather Service,
Scott Air Force Base, Illinois

The practice, in meteorology, of using interchangeably the words *subcooled* and *supercooled* (and also *undercooled*) when referring to liquid water which has been cooled to temperatures colder than 0°C is unfortunate indeed. To this extent I agree heartily with Appleman.

However, I cannot agree that it would be preferable to restrict ourselves to the term *supercooled.* My reason for preferring *subcooled* and *undercooled* is etymological. The point of reference which is implied in the use of all such words (for example, *superheated, supersaturated, subsaturated*) is that of the equilibrium condition. In this context the prefix *sub* denotes *under, below, beneath,* whereas *super* denotes *over, above*; therefore it seems preferable to use the terms *subcooled* and *superheated* when referring to a phase which has been cooled below or heated above its equilibrium temperature. On etymological grounds the term *undercooled* is even more desirable than *subcooled* because it is usually regarded as undesirable to mix words of Latin-Greek and Anglo-Saxon roots.

I consider it unfortunate that most desk-size dictionaries list *supercooled* but not *subcooled.* However, I have learned from one of the compilers that the 1959 edition of the *Weather Glossary* will cite *subcooled* as preferable to *supercooled.* I also find many other scientists who feel that it is desirable to make this change in nomenclature [for example, see Johnson, *Physical Meteorology,* p. 240; MacDonald, *Advances in Geophysics,* p. 245].

ROSCOE R. BRAHAM, JR.
Department of Meteorology,
University of Chicago



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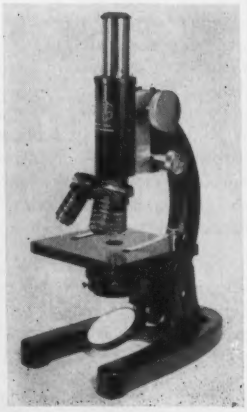

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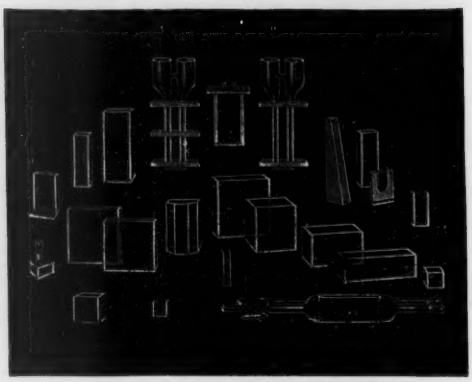

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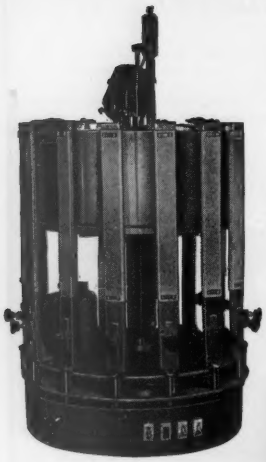

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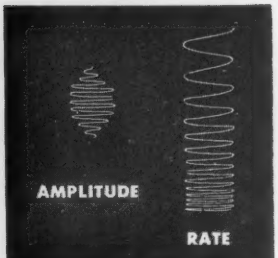

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